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GEOLOGICAL SURVEY OF ILLINOIS,

A. H. WORTHEN, DIRECTOR.

VOLUME VII.

GEOLOGY AND PALÆONTOLOGY

GEOLOGY,

By A. H. WORTHEN.

PALÆONTOLOGY,

By A. H. WORTHEN, ORESTES St. JOHN and S. A. MILLER,
WITH AN ADDENDA
BY CHARLES WACHSMUTH AND W. H. BARRIS.

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PREFACE.

This volume has been prepared and will be published under the provisions of an act of the Thirty-second General Assembly, authorizing the publication of Volume 7 of the Geological Survey of Illinois, approved May 26, 1881.

The first section of the volume is devoted to economical geology, and mainly to a record of the development of the coal resources of the State since the publication of the last preceding volume in 1875. The mining interests of the State are now second only in importance to those of agriculture, and although the information obtainable in regard to many of the experiments made with the drill, as well as that to be derived from the shafts but recently sunk within the borders of our coal-producing area, has in many cases been incomplete and unsatisfactory, through the non-preservation of the records kept by those having the work in charge, yet the data obtained, although by no means as complete as could be desired, will, I trust, prove of considerable value, and tend to the further development of this important industry.

Sections two and three are devoted to the description and illustration of the fossil forms belonging to the Carboniferous formation of the Mississippi valley, and, as these are mostly new to science, their publication will constitute an additional, and, I trust, an acceptable contribution to our present knowledge of the specific character of the Carboniferous fauna of the North American continent.

In our work on the vertebrates, I have had the assistance of Mr. Orestes St. John, of Topeka, Kansas, whose familiar acquaintance with the fossil fishes of the palæozoic rocks render his work of special value to those interested in this department of palæontology.

In the investigation of fossil echinoids, I was so fortunate as to secure the assistance of S. A. Miller, Esq., of Cincinnati, whose familiarity with that class of organism renders his determinations of more than ordinary value, and his work has resulted in the satisfactory elucidation of some very difficult and rather unsatisfactory material.

The illustrations for this volume were mostly drawn by Mr. Charles K. Worthen, and are faithful reproductions of the original specimens; and the plates have been engraved and printed by Messrs. Julius Mayer & Co., of Boston, in their usual excellent style.

One hundred and sixty-five plates of fossils have been published in the preceding volumes of the Geological Survey of Illinois, which, with those contained in the present volume, brings the aggregate number now published up to one hundred and ninety-six, nearly all of which have been devoted to the illustration of species new to science, and mainly obtained in prosecuting the field work of the geological survey, from formations existing within the borders of the State.

The work, however, is by no means complete, and at least two volumes more, illustrated by forty to fifty plates each, would be required to complete the palæontology of the State in the manner originally contemplated. These volumes should also include such economical results as may be obtained in the meantime by future investigations.

Nothing further can be done in this direction, however, until provision is made for it by a special act of the General Assembly, and it remains for the legislative authorities to determine whether the work shall be continued and eventually completed, in accordance with the original plan, or cease with the publication of the present volume.

A. H. WORTHEN.

CHAPTER I.

ECONOMICAL GEOLOGY.

Coal.—The extensive area of the Illinois Coal Field, covering more than thirty-six thousand square miles of territory within the boundaries of this State, is now under a process of rapid development, and the liberal expenditure of capital and labor in this special field of human industry during the last decade, has resulted in placing Illinois as the second on the list of coal producing States of the Union. No other mineral resource within our borders is at all comparable in intrinsic value with our coal deposits, and their complete development is a subject of vital interest to the commonwealth, and deserves to be encouraged by all legitimate means.

The abundance of coal, the wide area over which it extends, and the facility with which it can be mined, and the low price at which it has been placed upon the market, has been a leading cause of the great increase in our railroad facilities and manufacturing industries, thus adding vastly more than the intrinsic value of the coal product alone, to the material wealth of our people. It has enabled us to compete successfully with the water powers of New England in the manufacture of our raw products, and thus saves the cost of a double transportation to which our people were heretofore subjected, in the transfer of our raw products to the eastern manufacturers, and the manufactured product back to the great food producing centers of the Mississippi valley.

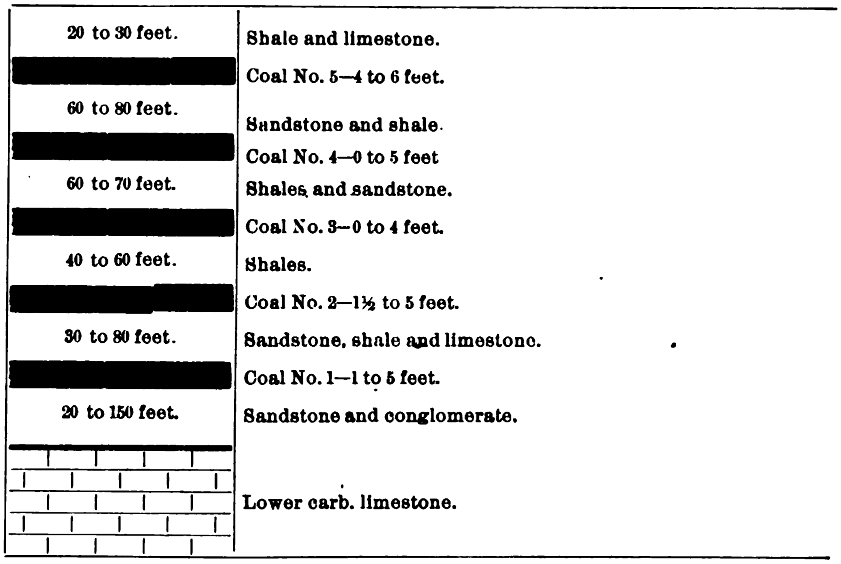
In Rock Island county, where only the lower seam, or No. 1 of the general section of the Illinois Coal Measures, is found thick enough for profitable mining, and where it has been relied on for the supply of the entire region north of the Rock Island rapids for the last thirty years or more, the supply is now well nigh exhausted, and the counties lying further east and south must now be resorted to for the future supply of that region. Rock Island county lies on the extreme northwestern borders of the coal field, and the Coal Measures there rest upon Devonian limestone, the whole of the lower Carboniferous series of limestones, sandstones, shales, etc., having thinned out in a northerly direction before reaching the southern borders of that county.

The Devonian limestone in this county presented an uneven surface for the reception of the overlying coal deposits, and consequently the coal itself was not found of uniform thickness, being often much thicker in the depressions of the limestone than elsewhere, and sometimes giving out altogether on the higher portions of the underlying beds. This has made the business of prospecting for coal in this county rather precarious for some years, and led to the expenditure of a considerable amount of capital that has yielded no adequate return.

But it is clear, as these experiments show, that the main deposit of coal in this county is now well nigh exhausted, and prospectors will do well to turn their attention to the counties lying to the eastward, where the higher seams may be found.

For the benefit of those who may not have access to the preceeding volumes of these reports, the following condensed section of the Coal Measures of this State is here inserted.

180 to 200 feet.	Sandstone and shale with a six inch seam of coal.
▬	Coal No. 16—1½ to 3 feet.
75 to 100 feet.	Sandstone and shale.
▬	Coal No. 15—1 to 3½ feet.
50 to 60 feet.	Sandstone and shale.
▬	Coal No. 14—1½ to 2 feet.
80 to 90 feet.	Sandstone and shale.
▬	Coal No. 13—0 to 3 feet.
75 to 80 feet.	Sandstone and shale.
▬	Coal No. 12—0 to 1 foot
20 to 25 feet.	Shales and limestone.
▬	Coal No. 11—0 to 1 foot.
30 to 40 feet.	Shales.
▬	Coal No. 10—0 to 1 foot.
80 to 90 feet.	Sandstone, shales and limestone.
▬	Coal No. 9—0 to 2 feet.
60 to 70 feet.	Sandstone, shale and limestone.
▬	Coal No. 8—1 to 2 feet.
80 to 100 feet.	Sandstone, shale and limestone.
▬	Coal No. 7—1 to 9 feet.
20 to 30 feet.	Sandstone, shale and limestone)
▬	Coal No. 6—0 to 6 feet.



Of the six lower seams represented in the foregoing condensed section, where they outcrop in the valley of the Illinois river, five are found of sufficient thickness to be profitably mined at some points and will afford an aggregate thickness of about twenty feet of marketable coal. They are not everywhere of uniform thickness, however, as for example, No. 1, at Seville, in Fulton county, is three feet or more in thickness, while at the outcrop, south of Lewistown, on the north bank of Spoon river, it is too thin to be profitably mined. At Prairie City it is reported at 3½ feet in the shaft recently sunk at that point, while in the vicinity of Colchester it is nowhere thick enough to work, and is often absent altogether, or represented by a bed of bituminous shale.

At Roodhouse, in Greene county, this seam was reached at the depth of about ninety feet, passing through the following beds:

	Ft.	In.
Drift clay, soil, etc	75	
Blue and ash-colored clay shale	15	
Black shale	1 ft. to 1	3
Coal	2	4
Fire and potters' clays	18	

This is probably the equivalent of the Battery Rock coal, which outcrops in the bluffs of the Ohio river a few miles below the mouth of the Saline, and is there associated with the heavy bed of conglomerate that forms the base of the Coal Measuress in Southern Illinois. The coal is there only about 18 inches thick, and the mines formerly opened there have generally been abandoned.

Coal No. 2, however, is very uniform in its development, though it seldom attains a thickness of more than three or three and a half feet. The superior quality of the coal which it affords has led to its being mined wherever it can be reached at a moderate depth. Along the western and northern borders of the coal field it has generally a very uniform thickness of about two feet, but in the vicinity of Murphysboro, in Jackson county, it is a double seam, the upper division being three feet and the lower two feet in thickness. In the vicinity of LaSalle it is the lowest coal found, and there has an average thickness of about 2½ to 3½ feet.

Coal No. 3 is a very uncertain seam, and is more frequently represented by a bed of bituminous shale than by a true coal. It has been mined at Atkinson, in Henry county, where it ranges in thickness from three to three and a half feet of good coal. It also outcrops in Fulton county, three miles northwest of Fairview, showing about eighteen inches of good coal. The lower seam in the Bloomington shaft I am also inclined to refer to this coal, and it is there three feet eight inches in thickness. In Gallatin and Saline counties there is a three-foot coal which occupies about the same position in those counties that No. 3 occupies in the valley of the Illinois river, but as the thicker seams lying above it are easily accessible, but little attention has been given to the lower seams.

No. 4 is also an uncertain seam and has only been identified at two or three points in the State. In Gallatin county it was found two and a half feet in thickness, and it has been identified at one or two points in Fulton county. Away from the borders of the coal field, nothing is at present known as to the development of these lower seams, all experiments being usually ended when the first workable coal is reached. A boring at Riverton, seven miles east of Springfield, is the only one near the center of the State that has been carried entirely through the Coal Measures.

The following is the report of that boring, furnished by Mr. C. B. Swan, the contractor, commencing below coal No. 5 and extending to the base of the Coal Measures:

	Ft.
Bottom of coal	237
Fire clay	4
Limestone	4
Black shale	25
Clay shale	35
Coal No. 4(?)	4
Fire clay	2
Clay shale (soapstone)	20
Limestone	25

	Ft.
Limestone(?)	15
Black shale	10
Coal No. 3(?)	1
Fire clay	3
Gray shale	20
Limestone(?)	15
Black shale	11
Coal No. 2	5
Fire clay	2
Sandy shale	14
Black shale	10
Limestone(?)	20
Sandstone	63
Blue shale	16
Coal No. 1	4
Fire clay	1
Shale and sandstone	67
	655

Having no other section through the lower portion of the Coal Measures in this part of the State for comparison, I am not prepared to say how far the above report can be depended on as correct. The beds reported as limestones 40, 15 and 20 feet in thickness, were probably in part at least hard sandstones, as no such heavy beds of calcareous rocks are anywhere known in the State below the horizon of the Riverton coal. At Olney, in the south part of the State, a boring for artesian water was made to the depth of two thousand feet, passing through only one coal seam, which was found at a depth of eleven hundred and sixty feet from the surface. A section of this shaft will be given further on in this report. From this boring it would seem that all the coal seams save one have thinned out in that portion of the State.

At Canton, in Fulton county, a boring for artesian water was recently made by Messrs. Atwater & Co., commencing above the horizon of coal No. 5 and extending through the lower Carboniferous limestones and into the Silurian rocks below. The following section will exhibit the lower Coal Measure strata passed through in this boring:

	Ft.	In.
Surface deposits, soil, clay, etc	40	
Shale	40	
Coal No. 5	4	6
Shale	15	
Limestone(?)	20	
Shale	61	
Slate (horizon of coal No. 3)	15	
Shale	30	
Coal No. 2	1	6
Fire clay	6	

	Ft.	In.
Shale	15	
Hard sandstone	5	
Shale	35	
Coal	1	
Slate and shale	62	
	358	

Only two thin seams of coal were found here below No. 5, neither of which were thick enough to be of any practical value. No. 1, which at Seville, about sixteen miles west of Canton, is three feet thick, was only one foot at Canton, and it is also about the same at its outcrop in the bluffs of Spoon river, south of Lewistown.

Coal No. 5, or the Springfield coal, as it is sometimes called, is perhaps the most reliable and persistent seam in its development of any in the State. Its average thickness is about six feet, and its range from four to eight. From Bloomington to Carlinville, along the line of the St. Louis, Alton and Chicago railroad, it has been found at every point where a boring or shaft has been carried down to the proper depth; and recently a shaft has been sunk to it at Decatur, where it was found at a depth of about six hundred feet. At Sandoval and Centralia, a seam averaging about the same in thickness is found at about the same depth, which may be the equivalent of the Springfield coal. At all these points the seam is about six feet in thickness, and it probably affords at this time more than one-half of the entire coal product of the State. There are now seven coal shafts in operation on this seam within two miles of the State capital, and nearly as many more within the limits of Sangamon county. The roof is usually composed of a hard black slate overlaid by a few feet of argillaceous limestone, the former containing numerous fossil shells, by which it may usually be readily identified.

Coal No. 6 is mined at several localities in Fulton and Peoria counties, where it ranges from four to five feet in thickness. It affords a coal somewhat softer than that from No. 5, but freer from sulphur, and therefore better adapted for forging iron. The seam is more irregular in its development than No. 5, and consequently is neglected except when a superior quality of coal is required for the smith's forge, or some other special use. In the shafts in Sangamon county, it ranges from a few inches to three feet in thickness, but no attempt has been made to work it in any of those in operation at the present time.

Coal No. 7 is well developed on the northern, eastern and southern borders of the Illinois coal field, ranging in thickness from four to seven feet. On the western borders of the field it is usually only from one to three feet thick; and is generally neglected for the thicker seams below. It is the main seam at Danville, the upper seam of workable coal in the shafts in La Salle county, and the main seam in Gallatin, Saline and Williamson counties, where it sometimes attains a maximum thickness of eight or nine feet. In the last named county an excellent coke is made from it, which finds a ready market in St. Louis for the use of the iron foundries at that point.

This is a brief *résumé* of the coal seams in the lower Coal Measures, as they appear around the borders of the coal field, and it is from this part of our coal area that our present supply of coal is mainly obtained. The shaft at Decatur has demonstrated that at least one of our main coals has retained its average thickness to the center of the field, and future experiments with the drill must determine whether any of the coals below No. 5 can be made available, when the supply from that has been exhausted. All experiments with the drill in the central and southeastern portions of the State, whether undertaken in search of coal or for any other purpose, should be carefully conducted, with the end in view of determining, as far as possible, the extent of our coal resources in that portion of the State, where the main coals, if present at all, are from six hundred to a thousand feet or more below the surface.

The increase in the coal products of the State from 1867 to 1880 was about 400 per cent., the product of 1867 being about 1,500,000 tons, while according to the U. S. census report for 1880 the product of that year is placed at 6,089,514 tons, equal to an annual increase of about 30 per cent. The census report, moreover, includes only such mines as are worked in the regular way, while there is a large amount mined annually for local use by the process of "stripping" on the outcrops of the thinner seams, of which that report would have no record. This would no doubt swell the amount for 1880 to at least 6,250,000 tons. This increase of our coal products has been mainly on the northern and western borders of the field, where the coal deposits are the most accessible; and the facilities for market are better than in other portions of our coal area.

At Olney a boring was made about two years since in search of artesian water, and the following record of the work was furnished by Mr. Victor E. Phillips, of Olney. The boring was carried to the depth of 2,000 feet, and failed to find flowing water. About 1,270 feet appears to have been through the Coal Measures, and one seam of coal five feet in thickness was passed at the depth of 1,160 feet. The following is a copy of the log kept by Mr. Phillips:

		Feet.	Total.
1.	Soil and clay	12	
2.	Sandstone	18	30
3.	Arenaceous shale	110	140
4.	Sandstone	25	165
5.	Shale	131	296
6.	Limestone	8	304
7.	Sandstone	30	334
8.	Argillaceous limestone	15	349
9.	Shale	382	731
10.	Black slate	4	735
11.	Shale with limestone bands	108	843
12.	Limestone	6	849
13.	Shale	1	850
14.	Limestone	6	856
15.	Ferruginous shale	4	860
16.	Calciferous shale	20	880
17.	Brown shale	70	950
18.	Light blue shale	85	1,035
19.	Sandy limestone	42	1,077
20.	Blue shale	3	1,080
21.	Brown shale	9	1,089
22.	Sandy limestone	50	1,139
23.	Black slate	16	1,155
24.	Coal	5	1,160
25.	Limestone—bottom arenaceous	40	1,200
26.	Shale	10	1,210
27.	Black slate	6	1,216
28.	Shale	15	1,231
29.	Sandy shale	40	1,271
30.	Sandy limestone	60	1,331
31.	Shale	15	1,346
32.	Limestone	69	1,415
33.	Calcareous sandstone	55	1,467
34.	Sandstone	33	1,500
35.	Clay shale	40	1,540
36.	Sandy shale with bands of black slate	160	1,700
37.	Sandy shale	70	1,770
38.	Calcareous sandstone	40	1,810
39.	Red sandstone	70	1,880
40.	White sandstone	50	1,930
41.	Brown sandstone	30	1,960
42.	Sandy limestone with thin seams of slate	40	2,000

The bottom of the Coal Measures was probably reached about No. 30 or 31, and all below those numbers may be referred to the lower Carboniferous, or to subordinate strata. It is quite remarkable that a boring should be carried through so great a thickness of Coal

Measure strata without meeting more than one well defined seam of coal, and it seems quite probable that some of the beds reported as black slate may also represent the horizon of thin beds of coal, the material being so mixed with the slate as to prevent identification.

Since the publication of volume 6, of these Reports, a shaft has been sunk at Sandoval, reaching a thick bed of coal at the depth of 602½ feet. The following is a copy of the record of this shaft:

		Ft.	In.
No. 1.	Surface deposits, clay, gravel, etc	127	8
No. 2.	Shale and sandstone	78	
No. 3.	Blue shale	16	
No. 4.	Limestone (Shoal creek bed)	10	
No. 5.	Black shale	3	6
No. 6.	Coal	0	2
No. 7.	Fire-clay	4	6
No. 8.	Sandstone and shale	67	6
No. 9.	Black shale	2	
No. 10.	Limestone	0	6
No. 11.	Fire clay	5	
No. 12.	Sandstone and shale	109	
No. 13.	Coal	1	2
No. 14.	Fire-clay	2	
No. 15.	Sandy conglomerate	5	
No. 16.	Sandstone and shale	88	8
No. 17.	Fire clay	2	
No. 18.	Pebbly clay	4	
No. 19.	Clay shale	11	
No. 20.	Blue slate	1	8
No. 21.	Coal	0	10
No. 22.	Fire clay	10	
No. 23.	Nodular blue shale	10	6
No. 24.	Gray limestone	2	8
No. 25.	Blue shale	2	
No. 26.	Gray limestone	2	6
No. 27.	Blue shale	3	
No. 28.	Dark shale	12	
No. 29.	Coal	6	6
	Total depth	609	

At Breese, twenty-two miles west of Sandoval, the coal was found at the depth of 397½ feet, but no detailed record of the beds passed through was kept. The coal ranges from seven to eight feet in thickness, and has a clay parting an inch or two thick, about two feet from the bottom. A bed of light gray limestone, ten feet in thickness, was passed through some twenty-five to thirty feet above the coal. The roof consists of bituminous shale, containing *Discina nitida* and the spines and dermal plates of fishes. The coal is considerably impregnated with the bi-sulphuret of iron, and is generally inferior in quality to that obtained from the Troy shaft, in Madison county. A bed of gray limestone, probably the Shoal creek rock, was found in this shaft immediately below the surface deposits, which were here only about 25 feet in thickness.

At Trenton the shaft is 320 feet in depth to the top of the coal. No detailed record of this shaft was kept. The coal is five feet in thickness, and of excellent quality, and is said to bring from one to one and a half cents per bushel more in the St. Louis market than the Collinsville and Caseyville coals. The roof shales contain *Leaia tricarinata*, which I regard as a characteristic fossil of coal No. 7.

At Troy, in Madison county, the shaft is 315 feet in depth to the top of the coal. The seam here is 5½ feet thick, and in quality it is equal to that obtained from the Trenton shaft. The shale over the coal is similar to that at Trenton, and contains the same fossils.

The Nashville shaft, in Washington county, is about 414 feet in depth to the top of the coal, and the following detailed record was made:

		Ft.	In.
No. 1.	Surface clay and gravel	38	
No. 2.	Blue shale	4	6
No. 3.	Limestone	6	6
No. 4.	Black slate	4	
No. 5.	Coal (middle slaty)	2	
No. 6.	Clay shale	6	
No. 7.	Sandstone and sandy shale	55	
No. 8.	Limestone	0	4
No. 9.	Blue shale	14	
No. 10.	Pebbly limestone	2	
No. 11.	Black slate	1	6
No. 12.	Fire-clay	4	
No. 13.	Clay shale	8	
No. 14.	Sandy shale and sandstone	47	
No. 15.	Blue shale (bottom slaty)	26	
No. 16.	Coal	1	2
No. 17.	Fire-clay	1	8
No. 18.	Lime conglomerate	4	6
No. 19.	Sandy shale	63	
No. 20.	Blue clay shale	42	6
No. 21.	Black shale	0	6
No. 22.	Fire-clay	1	8
No. 23.	Blue shale	3	
No. 24.	Fire-clay	4	6
No. 25.	Lime conglomerate	5	
No. 26.	Fire-clay	1	6
No. 27.	Hard limestone	15	10
No. 28.	Black shale	3	8
No. 29.	Blue pebbly shale	3	
No. 30.	Sandy shale and sandstone	14	
No. 31.	Fire-clay	1	6

		Ft.	In.
No. 32.	Shale	2	6
No. 33.	Limestone	4	2
No. 34.	Shale	2	6
No. 35.	Limestone	0	10
No. 36.	Dark blue shale	7	6
No. 37.	Limestone	8	
No. 38.	Black slate	2	8
No. 39.	Coal	7	6
	Total depth to bottom of coal	421	6

No. 3 of this shaft is undoubtedly the Shoal creek limestone, and the coal is here about 370 feet below it, which corresponds very nearly with its position in the Sandoval shaft, if the coal at these two points is identical, as is probably the case.

A shaft has been sunk at Okawville by Shulze & Brother, and an irregular seam of very good coal was reached at a depth of about 276 feet. This shaft commences below the horizon of the Shoal creek limestone, but as no detailed record of the beds passed through was made, no satisfactory conclusion could be formed as to the position of this seam in relation to that found at Nashville and Sandoval. It undoubtedly holds a higher position, and that seam may probably be found here by carrying the shaft down to the proper depth. If an accurate record of the strata passed through had been kept, some estimate of the additional depth required to reach a better seam might be given, but without it the question can only be settled by actual experiment.

The following record of a boring near Winchester in Scott county, made by the Manchester Mining Co., under the direction of Mr. G. R. Darling, was furnished by Mr. John C. Andrus. Manchester is located near the western borders of the Illinois coal field, and hence only about 120 feet of Coal Measure strata were found, including the horizon of coals No. 1 and 2, neither of which were thick enough to be of any practical value for deep mining:

		Feet.
No. 1.	Soil, clay and gravel	59
No. 2.	Fire-clay?	7
No. 3.	Slaty coal, (local)	1
No. 4.	Clay shale	10
No. 5.	Sandstone	1
No. 6.	Coal	2
No. 7.	Hard sandstone	7
No. 8.	Clay shale	10
No. 9.	Limestone	2
No. 10.	Soapstone	10
No. 11.	Sandstone	1
No. 12.	Clay shale	12

		Feet.
No. 13.	Shale and slate	13
No. 14.	Hard sandstone, (base of Coal Measures)	45
No. 15.	Shale	11
No. 16.	Hard silicious stone	4
No. 17.	Sandy shale	7
No. 18.	Slate	10
No. 19.	Hard limestone	8
No. 20.	Shale	20
No. 21.	Limestone and shale	10
No. 22.	Shale, very hard	31
No. 23.	Sulphuret of iron	1
No. 24.	Limestone and shale	2
No. 25.	Limestone	6
No. 26.	Shale	1
No. 27.	Hard limestone	21
	Total depth	312

All the beds below No. 14 of the foregoing section probably belong to the St. Louis and Keokuk divisions of the Lower Carboniferous series, and hence are below the horizon of any known coal.

At Roodhouse, about four miles southwest of Manchester, a shaft was sunk for coal, and the lower seam was found to be 2 feet 4 inches in thickness, with a good roof of black slate. The beds passed through, in sinking the shaft, were the following:

	Ft.	In.
Soil, clay and gravel, (drift)	75	
Blue and ash-colored clay shale	15	
Black slate	1 foot to 1	3
Coal	2	4
Fire-clay and clay shale	18	

A boring made here, struck the St. Louis limestone at a depth of about fifty feet below the coal. The roof of the Roodhouse coal is a hard black shale or slate filled with nodules of sulphuret of iron, which makes a permanent and substantial roof. The under clay seems to be of a good quality, and similar to that so extensively used at Whitehall for fire-brick and pottery. In Scott county, and in the central and western portions of Greene and Jersey, the two lower coals, Nos. 1 and 2 of the general section, are the only ones likely to occur; but on the extreme eastern borders of the last named counties, coals 5 and 6 are to be found on Hodge's creek, near the Greene county line, and a mile and a half west of Brighton, near the eastern border of Jersey county.

At Gillespie, in Macoupin county, a shaft has been sunk during the past year by B. L. Dorsey & Son, for the details of which I am indebted to Mr. Alexander Butters. Coal No. 5 was found here at the depth of about 365 feet, passing the following beds:

		Ft.	In.
No. 1.	Soil and drift clay	24	
No. 2.	Coarse limestone	4	
No. 3.	Black shale	2	
No. 4.	Coal, (No. 11)	0	1
No. 5.	Fire-clay	1	8
No. 6	Dark blue shale	3	
No. 7.	Limestone	0	6
No. 8.	Light-blue shale	30	
No. 9.	Coal, (No. 10)	0	4
No. 10.	Fire-clay	2	
No. 11.	Light and dark shales	40	
No. 12.	Fire-clay	20	
No. 13.	Bituminous shale	6	
No. 14.	Limestone, (Carlinville bed)	6	8
No. 15.	Bituminous shale	1	10
No. 16.	Coal, (No. 9)	0	3
No. 17.	Fire-clay	1	6
No. 18.	Light-colored shales	58	
No. 19.	Soft limestone	2	
No. 20.	Bituminous shale	3	
No. 21.	Coal, (No. 8)	0	7
No. 22.	Sandy shale	40	
No. 23.	Variegated shales with streaks of coal	17	
No. 24.	Sandstone in heavy beds, and shale	55	
No. 25.	Hard limestone	5	
No. 26.	Coal, (No. 6)	0	6
No. 27.	Fire-clay	1	8
No. 28.	Clay shale	8	
No. 29.	Limestone	27	
No. 30.	Black slate	2 to 4	
No. 31.	Coal, (No. 5)	7	10
	Bottom of coal	373	5

Several shafts have been sunk in Sangamon county since the publication of the former volumes of the geological reports, but in most cases no detailed record was kept. At Girard it was about 340 feet to coal No. 5. No details could be obtained of the first 190 feet, except that a six-inch seam of coal was found at the depth of 104 feet. The following is a record of the lower part of this shaft:

	Ft.	In.
Drift, clay, shales, etc., details not given	190	
Coal, (No. 8)	1	4
Shale, with iron bands at the base	71	
Fossiliferous limestone	0	10
Black shale	8	2
Coal, (No. 7)	1	
Fire-clay	2	9
Gray shale	19	
Fine black shale	1	8
Coal, (No. 6)		6
Fire-clay	3	3
Impure limestone	1	3
Hard gray sandstone	10	2
Dark gray shale	2	
Blue shale	1	1
Limestone	3	4
Light gray shale	3	3

	Ft.	In.
Impure limestone	1	3
Black shale	1	
Gray shale	2	10
Dark blue shale	6	
Fossiliferous limestone	2	
Dark gray sandstone	1	5
Shale and limestone	5	3
Fossiliferous limestone	4	
Black slate	0	6
Coal, (No. 5)	7	
Total depth	348	

At Auburn coal No. 5 was reached at a depth of 268 feet. The coal ranges from six to seven feet in thickness, with a good roof of black slate and limestone. No details of the shaft could be obtained.

In Menard county several shafts have been sunk since the publication of the report on that county, among which are those at Sweetwater, Athens, Greenview and Tallula. The following record of the Sweetwater shaft was kindly furnished me by Mr. W. Parkin:

		Ft.	In.
No. 1.	Soil and brown clay	20	
No. 2.	Hardpan	70	
No. 3.	Sand	10	
No. 4.	Clay	3	10
No. 5.	Black mucky soil (forest bed)	1	2
No. 6.	Clay with streak of smut six inches	9	6
No. 7.	Limestone	1	2
No. 8.	Clay shale	35	
No. 9.	Limestone	1	3
No. 10.	Bituminous shale	3	
No. 11.	Coal	5	6
No. 12.	Fire clay	6	
	Total depth	166	5

In this shaft they evidently struck the bed rock about the horizon of another coal seam, probably Nos. 6 or 7, as the lowest clay bed in the above section was reported to have a streak of black clay about three feet from the bottom six inches thick, which no doubt came from the decomposition of a black shale, or a thin seam of coal.

The Greenview shaft is 97 feet to the top of the coal. The seam is about six feet thick with a roof of black shale. Bed rock was struck at the depth of forty feet.

The Tallula shaft is 175 feet in depth. Coal five to six feet in thickness, with the usual black shale roof. The fire clay below the coal is reported to be 14 feet thick.

At Athens two shafts have been sunk. The first one was located in the creek bottom about three-quarters of a mile west of town, and is 155 feet in depth to the top of the coal. This shaft was sunk in 1869, and was worked mainly to supply the local demand for fuel. The new shaft is located near the railroad, and is 227 feet in depth. The coal averages about six feet in thickness, and has a good roof of black slate and limestone. Both are on the same seam, the difference in the depth of the shafts resulting from the higher surface level, where the new shaft is located. I visited Athens for the purpose of obtaining the necessary detailed information to enable me to report in full upon this shaft, but found no record available, and I learned that if such a record had been kept, it was not in the possession of the present owners of the mine.

The following report of a boring for coal at Virginia, in Cass county, was furnished by Mr. Joseph Wilson, who was employed by the parties interested to superintend the work:

		Ft.	In.
No. 1.	Soil and brown clay	7	
No. 2.	Yellow clay	2	6
No. 3.	Blue clay	29	8
No. 4.	Hardpan	28	
No. 5.	Forest bed (ancient soil)	3	
No. 6.	Hardpan	44	10
No. 7.	Sandstone	71	11
No. 8.	Hard limestone	1	1
No. 9.	Black shale	2	6
No 10.	Clay shale	10	3
No. 11.	Coal No. 2	3	6
No. 12.	Fire clay	3	
No. 13.	Black shale	0	3
No. 14.	Clay shale	7	6
No. 15.	Potter's clay	13	
No. 16.	Coal	0	2
No. 17.	Sandstone and shale	6	1
No. 18.	Coal	0	3
No. 19.	Sandstone and shale	6	9
No. 20.	Coal	0	8
No. 21.	Sandstone and shale	16	4
No. 22.	Coal	0	3
No. 23.	Sandstone	2	9
No. 24.	Coal	0	2
No. 25.	Sandstone and shale	3	9
No. 26.	Clay shale	4	
No. 27.	Sandstone	7	5
No. 28.	Hard silicious rock	2	
No. 29.	Clay shale	2	6
No. 30.	Hard silicious rock	3	6
No. 31.	Hard green shale	2	10
No. 32.	Limestone	9	1
No. 33.	Sandstone	1	8

		Ft.	In.
No. 34.	Limestone	62	4
No. 35.	Sandstone	8	
No. 36.	Gray limestone	1	
No. 37.	Sandstone	2	
No. 38.	Limestone	2	3
No. 39.	Sandstone	18	
No. 40.	Drab clay shale	6	6
No. 41.	Sandy shale	5	3
No. 42.	Shaly limestone	4	1
No. 43.	Quartz band	0	4
No. 44.	Shaly limestone	3	8
No. 45.	Clay shale	0	6
No. 46.	Shaly limestone	16	9
No. 47.	Yellow flint band	0	1
No. 48.	Clay shale	3	7
No. 49.	Hard gray limestone	4	1
No. 50.	Shaly limestone	6	2
No. 51.	Shale with bryozoans	2	2
No. 52.	Shaly limestone	4	7
		449	6

The coal from No. 8 of this boring appeared to be of excellent quality, and if the roof proves to be sufficiently firm, the seam can be worked to good advantage. Nos. 16 to 24 represent the horizon of coal No. 1, divided here into five thin seams of only a few inches in thickness, and too thin in the aggregate to be of any practical value.

The base of the Coal Measures is probably the hard silicious rock No. 30, while Nos. 31 to 39 represent the St. Louis and Warsaw beds, and all below and including No. 40 belong to the Keokuk limestone.

An unsuccessful attempt to obtain coal was made at Farmer City, by sinking a shaft to the depth of 163 feet without reaching bed-rock, and then boring to the depth of about 313 feet below the bottom of the shaft, making a total depth of 476 feet. For the details of this boring I am indebted to Mr. Sowdon, under whose supervision it was made.

	Ft.	In.
Shaft	163	
Blue clay	7	
Hardpan	18	
Clay shale	2	
Sandstone	4	5
Clay shale	46	3
Black shale	2	4
Coal	1	6
Fire clay	8	10
Gray sandstone	3	10
Clay shale	2	1

	Ft.	In.
Hard rock (limestone?)	8	1
Black shale	2	3
Clay shale	8	4
Limestone	6	4
Sandstone	1	5
Shale and slate	36	
Hard sandstone	3	8
Fire-clay	2	10
Shale	45	10
Soft sandstone	2	6
Clay shale	03	
Coal	1	5
Fire-clay	3	
Total depth	475	10

I am of the opinion that the coal seam at the bottom of this boring is number six or seven of the general section, and if so, number five would be found from fifty to seventy-five feet below, and would probably be from four to six feet in thickness.

A coal shaft has been sunk at Decatur to the depth of about 600 feet, but I have not been able to obtain any reliable information in regard to it, further than a copy of the published record of the boring made previous to sinking the shaft. I visited the locality shortly after the shaft was completed, and found, by an examination of the roof shales, that it was probably coal No. 5, and was told that it was about four and a half feet in thickness, although the published record of the boring gives but three feet six inches as the thickness of the coal. For the privilege of copying this record from a Decatur paper I am indebted to Mr. Stoddard, of Mattoon. That this boring is not quite reliable, is shown by the fact that it records a six foot one inch seam of coal at the depth of 413 feet, while the shaft was sunk to the depth of about 600 feet to a seam but little more than two-thirds the thickness of the one reported above. The coal passed through at the depth of 413 feet was probably coal No. 8 of the general section, which seldom exceeds two feet in thickness, and is often replaced entirely by bituminous shale. The following is a copy of the published record of this boring:

		Ft.	In.
No. 1.	Superficial deposits, consisting of clay, sand, hard-pan, and two distinct forest beds	110	6
No. 2.	Argillaceous shale	52	6
No. 3.	Bituminous shale	3	
No. 4.	Calcareous shale	14	
No. 5.	Marly sandstone	1	
No. 6.	Calcareous shale	32	

		Ft.	In.
No. 7.	Argillaceous sandstone	5	
No. 8.	Red shale	2	
No. 9.	Argillaceous limestone	8	
No. 10.	Brown shale	7	
No. 11.	Argillaceous limestone	2	
No. 12.	Calcareous shale	2	6
No. 13.	Coal and bituminous shale	2	
No. 14.	Calcareous shale	5	6
No. 15.	Brown shale	2	
No. 16.	Argillaceous sandstone	41	8
No. 17.	Coal	0	6
No. 18.	Argillaceous shale	8	6
No. 19.	Nodular limestone	9	
No. 20.	Calcareous shale	5	
No. 21.	Argillaceous shale	10	
No. 22.	Hard limestone	9	
No. 23.	Argillaceous shale	2	6
No. 24.	Bituminous shale	2	
No. 25.	Argillaceous shale	12	
No. 26.	Hard limestone	7	6
No. 27.	Argillaceous limestone	1	6
No. 28.	Black and gray shale	1	
No. 29.	Argillaceous shale	3	6
No. 30.	Argillaceous limestone	20	6
No. 31.	Argillaceous shale	9	
No. 32.	Argillaceous sandstone	27	6
No. 33.	Calcareous shale	2	
No. 34.	Bituminous shale	1	6
No. 35.	Coal	6	1
No. 36.	Argillaceous nodular shale	15	
No. 37.	Argillaceous slaty shale	19	
No. 38.	Hard gray limestone	17	
No. 39.	Soft shale	1	6
No. 40.	Bituminous shale	1	
No. 41.	Argillaceous shale	4	6
No. 42.	Brown shale	0	6
No. 43.	Calcareous shale	9	3
No. 44.	Argillaceous limestone	2	
No. 45.	Calcareous shale	3	3
No. 46.	Red variegated shale	9	
No. 47.	Gray argillaceous shale	18	
No. 48.	Bituminous shale	3	3
No. 49.	Gray argillaceous shale	1	3
No. 50.	Bituminous shale	1	6
No. 51.	Gray, calcareous shale	6	
No. 52.	Bituminous shale	1	
No. 53.	Coal and limestone	1	
No. 54.	Bituminous shale	0	6
No. 55.	Soft limestone	1	
No. 56.	Argillaceous shale	2	
No. 57.	Bituminous shale	0	7
No. 58.	Coal	0	8
No. 59.	Gray shale	0	9
No. 60.	Argillaceous limestone	6	9
No. 61.	Shale	0	6
No. 62.	Limestone	2	10

		Ft.	In.
No. 63.	Coal	0	6
No. 64.	Blue and gray shales	14	5
No. 65.	Marly sandstone	1	6
No. 66.	Calcareous shale	5	
No. 67.	Sandstone	15	
No. 68.	Gray slate	5	9
No. 69.	Bituminous shale	2	3
No. 70.	Coal	3	6
No. 71.	Fire-clay	2	
	Total depth	608	9

No. 22 is probably the Carlinville limestone, and No. 35 the representative of No. 8 coal, and beyond this the strata cannot be positively identified with those occurring at other localities in the adjacent portions of the State.

In the Niantic shaft, coal No. 5 was found at the depth of about 850 feet. The seam was there five and a half feet in thickness, overlaid by three feet of black shale. The following record of the shaft was furnished by Mr. W. W. Conard, under whose superintendence the work was done:

		Ft.	In.
No. 1.	Soil and brown clay	11	
No. 2.	Sand and gravel	4	
No. 3.	Gravelly hard-pan	25	
No. 4.	Blue hard-pan	10	
No. 5.	Soft clay	15	
No. 6.	Gray hard-pan	10	
No. 7.	Soft brown clay	7	
No. 8.	Limestone	10	
No. 9.	Blue flinty rock	2	
No. 10.	Black slate	3	
No. 11.	Fire-clay	6	
No. 12.	Limestone	10	
No. 13.	Blue and gray shale	7	
No. 14.	Black shale	1	
No. 15.	Coal No. 9	0	2
No. 16.	Fire-clay	1	
No. 17.	Nodular limestone	5	
No. 18.	Clay shale	5	
No. 19.	Soft blue sandstone	16	
No. 20.	Gray shale	42	
No. 21.	Coal No. 8	1	3
No. 22.	Fire-clay	2	6
No. 23.	Sandstone	10	
No. 24.	Gray shale	45	
No. 25.	Hard flinty rock	10	
No. 26.	Black shale	3	
No. 27.	Fire-clay	9	
No. 28.	Blue and red shales	15	
No. 29.	Black slate	5	
No. 30.	Coal No. 7	1	3
No. 31.	Fire-clay	4	6

		Ft.	In
No. 32.	Black shale	11	
No. 33.	Coal No. 6	2	6
No. 34.	Clay shale	15	
No. 35.	Black shale	3	
No. 36.	Coal (local)	0	10
No. 37.	Fire-clay	2	
No. 38.	Gray shale	14	
No. 39.	Hard black rock (limestone)	1	
No. 40.	Black slate	3	
No. 41.	Coal No. 5	5	6
	Total depth	354	6

All the coal seams from 5 to 9 are clearly represented in this shaft, and are readily identified. It is to be regretted that such records are not kept of every shaft sunk in the State, for they would be of permanent value to the proprietors and operators alike, in settling many questions that necessarily arise in coal mining operations, and would prove a source of scientific as well as economic information to all who desire to become acquainted with the fuel resources of the State. In visiting the various shafts that have been sunk within the past three or four years, I have found that not more than one-third of the whole number have preserved any record whatever of the different beds passed through.

Two very important experiments have been made during the past two years, to determine whether the main coal seams could be found available over the central portion of the Illinois coal field, and both have proved successful. The first one undertaken was the shaft at Mattoon, which is probably the deepest one west of Pittsburg. In this, coal No. 2 of the general section was found at the depth of about 900 feet. No. 5 was passed at a depth of nearly 700 feet, but was found to be too thin to be of any practical value. For the following details of the Mattoon shaft I am indebted to Theo. Jonte, Esq., and Mr. Stoddard:

MATTOON SHAFT.

		Ft.	In.
No. 1	Surface soil	5	
No. 2	Yellow clay	8	
No. 3.	Blue sand	8	
No. 4.	Hard-pan	35	
No. 5	Sand and gravel	17	
No. 6.	Blue clay and gravel	38	
No. 7.	Green clay shale	15	
No. 8.	Limestone	1	6
No. 9.	Clay shale	23	
No. 10.	Limestone	2	
No. 11.	Coal No. 15	0	4
No. 12.	Fire-clay	4	

		Ft.	In.
No. 13.	Clay shale	83	
No. 14.	Black shale and coal (coal No. 14)	5	
No. 15.	Red shale	20	
No. 16.	Sandstone and lime	108	
No. 17.	Coal No. 13	1	6
No. 18.	Fire-clay	3	6
No. 19.	Clay shale	66	
No. 20.	Coal No. 12	0	8
No. 21.	Fire-clay	3	
No. 22.	Sandstone	6	
No. 23.	Coal No. 11	0	7
No. 24.	Fire-clay and shale	11	
No. 25.	Coal No. 10	0	11
No. 26.	Fire-clay	4	
No. 27.	Limestone, upper part shaly	37	
No. 28.	Coal No. 9	0	4
No. 29.	Sandy shale	79	
No. 30.	Clay shale	28	
No. 31.	Coal No. 7 1 ft. 6 in. to	2	6
No. 32.	Dark clay shale	2	6
No. 33.	Coal	0	2
No. 34.	Fire clay	3	
No. 35.	Gray shale	12	
No. 36.	Limestone	15	
No. 37.	Black slate 2 feet, coal 1 inch (coal No. 6)	2	1
No 38.	Clay shale	36	
No. 39.	Coal No. 5	1	1
No. 40.	Sandstone and shale	72	
No. 41.	Coal No. 3	0	11
No. 42.	Fire clay	2	5
No. 43.	Limestone	8	
No. 44.	Blue shale	2	
No. 45.	Hard gray limestone	12	
No. 46.	Sandy shale	58	
No. 47.	Sandstone and shale	46	
No. 48.	Gray shale	19	
No. 49.	Coal No. 2	4	
	Total depth	908	

No indications of coal No. 4 were noticed, and its place is about midway between coals 3 and 5, but with that exception the whole series from No. 2 to 15 come in in regular order, and are readily identified. The product from No. 2 in this shaft is a clean bright coal, apparently nearly free from iron pyrites, and, judging from its external appearance, sufficiently free from all deleterious substances to be used in its raw state for smelting iron. A block of the roof shale of No. 5 was sent to my office by Mr. Jonte, and I found it filled with *Discina nitida*, *Lingula mytiloides* and *Cardinia? fragilis*, which characterize this coal in all the shafts in this and the adjoining counties, and fix the horizon of that coal in this shaft beyond question.

Great credit is due to the stockholders in this mining enterprise, and to the citizens of Mattoon generally, for their persevering efforts in bringing this costly experiment to a successful termination.

The other important experiment alluded to above, was made with the diamond drill at Pana, and was successful in finding a coal seam about seven feet in thickness at the depth of a little over 700 feet. For the following details of this boring I am indebted to J. W. Ketchell, Esq., of Pana, in whose office I was permitted to examine the core of rock taken out with the drill as the work progressed:

PANA BORING.

		Ft.	In.
No. 1.	Soil and brown clay	11	
No. 2.	Hardpan	2	
No. 3.	Blue clay	2	
No. 4	Sand and gravel	12	
No. 5.	Hard red clay	18	
No. 6.	Forest bed	3	6
No. 7.	Blue clay	57	
No. 8.	Forest bed	2	6
No. 9.	Clay	19	4
No. 10.	Limestone	3	1
No. 11.	Clay shale with lime nodules	2	10
No. 12.	Clay shale—upper part red	8	3
No. 13.	Blue and gray limestone	16	10
No. 14.	Dark clay shale	1	4
No. 15.	Gray limestone	12	6
No. 16.	Sandy shale	2	10
No. 17.	Sandstone and shale	43	6
No. 18.	Fine grained sandstone	18	
No. 19.	Bluish clay shale	14	9
No. 20.	Coal No. 12	0	6
No. 21.	Black and gray shale	0	9
No. 22.	No core, probably fire-clay	4	2
No. 23.	Blue and chocolate colored shale	41	9
No. 24.	Calcareous shale with fossils	0	9
No. 25.	Coal No. 11	0	11
No. 26.	Pebbly fire-clay	4	5
No. 27.	Greenish clay shale	10	6
No. 28.	Sandy shale and sandstone	48	6
No. 29.	Clay shale	3	
No. 30.	Dark fossiliferous shale—coal No. 10	3	10
No. 31.	Sandy shale	16	11
No. 32.	Blue clay shale	3	1
No. 33.	Fossiliferous shale	0	8
No. 34.	Gray limestone	9	8
No. 35.	Blue clay shale	1	10
No. 36.	Black shale (No. 9 coal)	3	4
No. 37.	No core, probably fire-clay	2	
No. 38.	Sandstone	3	8
No. 39.	Calcareous sandstone and shale	22	2
No. 40.	Blue clay shale	28	8
No. 41.	Fossiliferous shale	0	10

		Ft.	In.
No. 42.	Black shale	4	7
No. 43.	Coal (local)	0	8
No. 44.	Fire-clay and nodular arg. limestone	11	1
No. 45.	Mottled dark sandstone	13	
No. 46.	Striped sandy shales	66	8
No. 47.	Clay shale	2	3
No. 48.	Fossiliferous shale	0	6
No. 49.	Coal No. 8	1	1
No. 50.	Shale and fire-clay	1	6
No. 51.	Sandy shales and sandstone	87	6
No. 52.	Coal No. 7	0	6
No. 53.	Dark clay shale	15	
No. 54.	Dark argillaceous limestone	0	6
No. 55.	Bituminous shale	4	
No. 56.	No core (soft calcareous shale?)	7	3
No. 57.	Hard pyritiferous rock	4	9
No. 58.	Coal No. 6	2	8
No. 59.	Hard clay shale	3	
No. 60.	Argillaceous limestone	3	6
No. 61.	Dark shale	5	2
No. 62.	Dark gray limestone	12	
No. 63.	Black shale	4	
No. 64.	Septaria (nodule)	0	10
No. 65.	Black shale	0	1
No. 66.	Coal	7	3
	Total depth	719	6

The surface deposits at Pana proved to be about 127 feet thick, and consequently they struck the bed-rock considerably below the horizon of coal No. 14, which outcrops on the creek two or three miles south of the city. No. 13 could not be identified in the boring, and its place would be not far below No. 15 of the section. One interesting feature of the superficial deposits here was the presence of two distinct *Forest beds*, or ancient soils, one three and a half and the other two and a half feet thick, and separated by 57 feet of blue clay. One or both of these ancient soils have been found over a large portion of the State, and they present a serious obstacle to the land ice or glacier theory of the origin of the Drift deposits.

Another important boring with the diamond drill has been made by the Ellsworth Coal Company, two miles west of Danville. This boring shows the general development of all the coals in the lower Coal Measures from No. 7 to the bottom of the series. It commences just below the Danville coal, which is No. 7 of the general section, and ends in the sandstone at the base of the Coal Measures. These lower seams have their outcrop in Indiana, and this is the first attempt that has been made on the eastern border of the coal region in Illinois to ascertain whether any of the lower seams could be found in that portion of the State of sufficient thickness to be of practical value.

DANVILLE BORING.

		Ft.	In.
No. 1	Coal No. 7		
No. 2	Shale	3	8
No. 3	Coal (lower division of No. 7)	0	6
No. 4.	Blue and gray shale	17	11
No. 5.	Black shale	1	11
No. 6	Coal No. 6 (Grape creek)	2	11
No. 7.	Fire-clay	2	7
No. 8.	Limestone and shale	6	5
No. 9.	Sandy shales	16	5
No. 10.	Gray shale	82	10
No. 11.	Black shale	8	
No. 12.	Dark gray shale	16	2
No. 13.	Sandstone and shale	14	4
No. 14.	Coal No. 4	1	6
No. 15.	Shale	9	4
No. 16.	Coal No. 3	0	8
No. 17.	Gray shale	1	6
No. 18.	Variegated shales, bottom black	23	
No. 19.	Coal No. 2	4	1
No. 20.	Shale and limestone	3	
No. 21.	Coal—upper division of No. 1	0	9½
No. 22.	Black shale	0	3
No. 23.	Coal—lower division of No. 1	1	9
No. 24.	Shale and sandstone	66	10
	Total	286	5

This boring has demonstrated that coal No. 2 may be found in this portion of the State with a more than average thickness of fou feet, and the superior quality of the coal which it affords will stimulate those largely interested in coal mining operations to carry their shafts down to this horizon, even where the thicker seams above are well developed. The Ellsworth Coal Company are entitled to the credit of making the first effort to ascertain what could be found on the eastern borders of the Illinois coal field below the horizon of coal No. 6.

On the western border of the coal field in nearly the same latitude, a shaft was recently sunk through the lower portion of the Coal Measures, but developing no coal that was more than thirty inches in thickness. For the following details of the shaft at Prairie City, in McDonough county, I am indebted to Mr. B. F. Worden, of that place:

		Ft.	In.
No. 1.	Soil and drift clay	37	
No. 2.	Black fissile rock	1	
No. 3.	Cannel coal—No. 4?	0	8
No. 4.	Clay shale	11	

		Ft.	In.
No. 5.	Coal No. 3	2	
No. 6.	Fire-clay	2	6
No. 7.	Sandstone	13	6
No. 8.	Clay shale	15	6
No. 9.	Coal No. 2	0	10
No. 10.	Clay shale	2	6
No. 11.	Hard rock	2	
No. 12.	Clay shale	19	
No. 13.	Calcareous sandstone	13	
No. 14.	Black shale	4	
No. 15.	Coal (local)	0	4
No. 16.	Fire-clay	1	
No. 17.	Sandstone	4	
No. 18.	Clay shale	13	6
No. 19.	Slate	8	
No. 20.	Coal No. 1	1	5
No. 21.	Cannel coal	0	7
No. 22.	Mixture of coal and slate	1	
	Total depth of shaft	154	4

From this point a boring was made to the depth of 38 feet, passing through the following strata:

	Ft.
Clay shale	22
Sandstone	8
Clay shale	4
Sandstone	4
Gray limestone (Lower Carboniferous).	

The gray limestone at the bottom of this boring is probably the upper division of the Lower Carboniferous series, and no coal would be found by sinking to a greater depth. Nos. 19, 20 and 21 of the shaft probably represent coal No. 1, while No. 15 represents a local seam. No. 9 is coal No. 2, No. 5 is coal No. 3, and No. 3 of the shaft is either a local development or a representative of coal No. 4

No. 18 is said to be an excellent quality of tile clay, and the shaft may be utilized in the production of this useful article for the manufacture of pottery and drain tile on a large scale.

A boring made at Milford, in Iroquois county, was carried to the bottom of the Coal Measures, reaching the Lower Carboniferous limestone at about 200 feet, and though two coal seams were passed through neither of them were thick enough to be of any practical value. The following beds were passed through in this boring:

	Ft.	In.
Clay, sand and gravel	110	
Clay shale	34	
Coal No. 2	1	3
Fire-clay	2	

	Ft.	In
Clay shale	20	
Sandstone	16	
Clay shale	2	
Coal No. 1	0	8
Fire clay	2	
Sandstone	5	
Shale	4	
Sandstone	3	
Lower Carboniferous limestone	0	6
Total depth	200	4

The following record of a boring made at Charleston, in Coles county, was furnished by Mr. C. B. Swan, under whose direction the work was done:

		Ft
No. 1.	Soil and surface clay	15
No. 2.	Hard-pan	15
No. 3.	Gray shale	30
No. 4.	Fire-clay	3
No. 5.	Shale	20
No. 6.	Limestone	4
No. 7.	Shale	3
No. 8.	Limestone	20
No. 9.	Green shale	2
No. 10.	Black shale	3
No. 11.	Limestone	7
No. 12.	Black shale	5
No. 13.	Gray slate	45
No. 14.	Coal	2
No. 15.	Fire-clay	3
No. 16.	Gray shale	28
No. 17.	Black shale	10
No. 18.	Coal	3
No. 19.	Fire-clay	3
No. 20.	Gray shale	16
No. 21.	Limestone	2
No. 22.	Black shale	9
No. 23.	Limestone	15
No. 24.	Light shale	43
No. 25.	Black shale	44
No. 26.	Red shale	10
No. 27.	Limestone	20
No. 28.	Clay shale	36
No. 29.	Coal	4
No. 30.	Fire-clay	4
No. 31.	Limestone	6
No. 32.	Clay shale	32
No. 33.	Limestone and shale	11
No. 34.	Sandy shale	40
No. 35.	Black shale	5
No. 36.	Coal	5
	Total depth	523

I am not able to correlate this boring, either with the shaft at Mattoon or the diamond drill boring at Pana. I am satisfied that it is not deep enough to reach the horizon of coal No. 5, but it is possible that the lowest coal reported in the boring may be No. 7, and if this conclusion is correct, No. 5 would be found at from 60 to 75 feet below. The limestones reported in this boring have no analogues any where else in the Coal Measures, either in the number of the beds or their aggregate thickness. Nos. 6, 8 and 11 constitute a calcareous mass 31 feet in thickness, with only about 8 feet of intervening shales, and in my examinations of the outcrops on the Embarras river, in this and the adjoining county of Cumberland, no such heavy beds of limestone were found.

The "*Fusulina*" limestone which outcrops in the vicinity of Greenup, and along the Embarras river at intervals nearly to the south line of Coles county, is nowhere more than five feet in thickness, and I found no calcareous shales of any considerable thickness associated with it that could be mistaken in the boring for limestone. This may be represented, however, by No. 6 of the boring, and the 20 foot limestone No. 8 may be the equivalent of the Quarry Creek limestone of Clark county, which is underlaid by a green shale there, and possibly agreeing with that reported under the limestone in this boring. Below this there are four other beds of limestone reported, varying in thickness from six to twenty feet, making an aggregate of some 80 or 90 feet. If this is a true record of the Coal Measure strata underlying Coles county, it shows a greater thickness of calcareous beds here than have been found elsewhere in the State.

BORING AT HARVEL.

		Feet.
No. 1.	Surface soil and clay	17
No. 2.	Sandy shale	3
No. 3.	Clay shale	56
No. 4.	Limestone	10
No. 5.	Clay shale	12
No. 6.	Limestone	5
No. 7.	Green shale	30
No. 8.	Black shale	4
No. 9.	Sandy shale	20
No. 10.	Clay shale	160
No. 11.	Limestone	3
No. 12.	Clay shale	30
No. 13.	Black shale	3
No. 14.	Clay shale	40
No. 15.	Limestone	2
No. 16.	Clay shale	10
No. 17.	Black shale	3

		Feet.
No. 18.	Clay shale	36
No. 19.	Limestone	7
No. 20.	Clay shale	26
No. 21.	Sandstone	3
No. 22.	Clay shale	8
No. 23.	Limestone	1
No. 24.	Black slate	2
No. 25.	Clay shale	10
No. 26.	Limestone	2
No. 27.	Clay shale	34
No. 28.	Sandy shale	4
No. 29.	Light gray sandy shale	85
No. 30.	Sandy shale	38
No. 31.	Clay shale	2
No. 32.	Sandy shale and sandstone	109
	Total depth	775

Harvel is about fifteen miles N.NE. of Litchfield, in Montgomery county, and on comparing the above boring with the shaft and boring at the latter locality, given on a subsequent page, it will be seen that there is no correspondence worthy of note between them. The thinning out and consequent disappearance of a coal seam in certain localities is not an unusual occurrence, but the entire absence of a half dozen seams where they might be expected to occur, is quite an extraordinary occurrence.

For the following record of the escapement shaft at Dawson, in Sangamon county, sunk by the Wabash Coal Company, I am indebted to Mr. Thomas P. Mowitt:

		Ft.	In.
No. 1.	Surface soil, clay and sand	60	
No. 2.	Clay shale, with bands of hard rock	105	
No. 3.	Blue shale	3	
No. 4.	Hard conglomerate	1	
No. 5.	Fire-clay	4	
No. 10.	Red shale	10	
No. 11.	Bastard slate	3	6
No. 12.	Coal No. 6	0	1
No. 13.	Fire-clay	2	
No. 14.	Hard brown rock	3	
No. 15.	Hard gray sandstone	36	
No. 16.	Clay shale	12	
No. 17.	Limestone (cap-rock)	1	
No. 18.	Black slate	2	6
No. 19.	Coal No. 5	5	
	Total depth	249	1

Dawson is 55 feet above the station at Riverton, where the Riverton coal shaft is located, and as the depth of the Dawson shaft was was not deep enough to allow for the average dip of the coal to the eastward, I was inclined to believe before seeing the record of the Dawson shaft that the seam they were working was No. 6, and that No. 5 was to be found some thirty or forty feet below. But on comparing the record of the shaft at Dawson with that at Riverton, I am convinced they are both on the same seam, though the dip between these points is scarcely more than one foot to the mile, while from the western outcrop of No. 5 to Riverton it averages about seven feet. From Dawson to Niantic it averages nearly the same, while from Niantic to Decatur it increases to at least twelve or fourteen feet to the mile.

Section of the Winona shaft at Winona, near the northeast corner of Marshall county, furnished by Mr. E. L. Monser:

		Ft.	In.
No. 1.	Soil and yellow clay	10	
No. 2.	Blue clay	46	
No. 3.	Sand	10	
No. 4.	Hardpan	34	
No. 5.	Red clay	3	
No. 6.	Soft clay shale	3	
No. 7.	Hard limestone	1	6
No. 8.	Brown shale	6	
No. 9.	Sandstone	7	
No. 10.	Blue shale	13	
No. 11.	Dark clay shale	4	
No. 12.	Limestone	13	
No. 13.	Gray slate	3	6
No. 14.	Black slate	3	
No. 15.	Coal (poor) No. 10?	0	6
No. 16.	Gray slate	11	
No. 17.	Blue shale	2	
No. 18.	Limestone (top hard)	11	
No. 19.	Brown shale	8	
No. 20.	Clay shale	6	
No. 21.	Hard sandstone	2	
No. 22.	Clay shale	4	
No. 23.	Brown shale	2	
No. 24.	Blue shale	6	
No. 25.	Hard limestone	2	
No. 26.	Blue shale	4	
No. 27.	Clay shale (gray)	17	
No. 28.	Blue shale	5	
No. 29.	Brown shale	14	
No. 30.	Blue sandstone	30	
No. 31.	Gray slate	14	
No. 32.	Dark shale	38	
No. 33.	Coal No. 7?	3	4
No. 34.	Fire-clay (top, good)	10	
No. 35.	Sandy shale	8	
No. 36.	Clay shale	18	
No. 37.	Black shale	3	
No. 38.	Dark shale	2	
No. 39.	Brown shale	3	

		Ft.	In.
No. 40.	Flint rock?	4	
No 41.	Dark slate	4	
No 42.	Nodular fire-clay	2	10
No. 43.	Brown shale	0	4
No. 44	Fire-clay	4	8
No. 45.	Sandy shale	3	6
No. 46.	Soft clay shale	1	8
No. 47.	Sandstone	15	6
No. 48.	Gray slate	5	8
No. 49.	Dark slate with iron bands	1	6
No. 50.	Gray slate with sulphur balls	21	6
No. 51.	Black slate, with fossil shells	4	
No. 52.	Gray shale, with shells and plants	15	8
No. 53.	Black slate	3	6
No. 54.	Blue clay shale	6	
No. 55.	Limestone in two bands, with 3 inches shale	1	1
No. 56.	Dark soapstone	4	
No 57.	Limestone	1	
No. 58.	Dark clay shale	2	6
No. 59.	Black slate	5	
No. 60.	Coal –upper 5 inches cannel, No. 4	1	2
No. 61.	Fire-clay	6	
No. 62.	Limestone	1	
No. 63.	Dark clay shale	2	6
No. 64.	Black slate	5	
No. 65.	Coal No. 3	1	2
No. 66.	Fire-clay	6	5
N°. 67.	Limestone	2	
No. 68.	Clay shale (light and dark)	22	2
No. 69.	Coal (poor)	0	4
No. 70.	Sandstone, with sulphur and 1 inch coal	4	6
No. 71.	Dark clay shale	13	
No. 72.	Hard sulphur rock	3	6
No. 73.	Black slate	4	6
No. 74.	Gray slate and shale	11	8
No. 75.	Coal No. 2	2	8
	Total depth	576	4

The coal at the bottom of this shaft is without doubt coal No. 2 of the general section, though it is not quite so thick here as it averages in LaSalle county. Quite possibly its average thickness will prove to be greater than the above figures may indicate. It is one of the most persistent seams in the State, and furnishes a better quality of coal usually than any of the others. Its freedom from sulphur is sometimes so complete that it can be used in the raw state for smelting iron.

A boring made at Marissa, in St. Clair county, commenced under the Belleville coal, shows that there is no coal seam of any value below that in that part of St. Clair county.

Boring at Marissa, commencing at the bottom of the Belleville coal:

		Ft.	In.
No. 1.	Fire-clay	7	11
No. 2.	Limestone or septaria	2	10
No. 3.	Fire-clay	1	
No. 4.	Septaria?	0	11
No. 5.	Clay shale, with concretions of iron ore	50	10
No. 6.	Black shale	5	6
No. 7.	Clay shale	33	
No. 8.	Blue slate, with nodules	18	3
No. 9.	Limestone	1	3
No. 10.	Black slate	6	
No. 11.	Coal	1	3
No. 12.	Fire-clay and coal	2	7
No. 13.	Fire-clay	5	4
No. 14.	Coal	0	10
No. 15.	Fire clay	11	6
No. 16.	Variegated shale	1	6
No. 17.	Light sandy shale	8	9
No. 18.	Dark limestone	0	3
No. 19.	Light micaceous sandstone	15	6
No. 20.	White fine grained sandy shales	50	1
	Total depth	225	1

Salt water commenced flowing in No. 17, and increased so as to stop further progress in No. 20. The lower coals are probably represented by Nos. 11 and 14, neither of which are of any practical value. The sandstone and sandy shale constituting the last 65 feet probably represent the sandstone usually found at the base of the Coal Measures.

The following is a record of a boring for coal made at Lementon, in St. Clair county, on the line of the B. & S. I. R. R., for which I am indebted to Mr. E. C. Leonard:

		Ft.	In.
No. 1.	Soil, clay and gravel	38	
No. 2.	Carbonaceous clod coal No. 6?	1	
No. 3.	Clay shale	11	
No. 4.	Red and yellow sand?	1	
No. 5.	Clay shale	12	
No. 6.	Hard rock	1	
No. 7.	Clay shale	7	
No. 8.	Black slate	9	6
No. 9.	Coal No. 5	1	6
No. 10.	Fire-clay and shale	34	
No. 11.	Hard rock	1	6
No. 12.	Black slate	3	6
No. 13.	Coal No. 3	0	2
No. 14.	Fire-clay and clay shale	9	
No. 15.	Brown shale	4	
No. 16.	Hard blue shale	9	
No. 17.	Blue slate	1	

		Ft.	In.
No. 18.	Sandstone	9	
No. 19.	Brown shale	1	
No. 21.	Sandstone	1	
No. 21.	Coal No. 2	1	
	Total depth	156	2

Although this boring commences above the horizon of No. 5 coal, it was found to be too thin at this point to be of any practical value, while the two lower seams penetrated in the bore were also valueless. This barren area is not very extensive, as No. 5 outcrops on Silver creek, about four miles a little east of north from Lementon, with its normal thickness of five to six feet. Probably a boring two or three miles east of this point would result in finding this seam of coal with its average thickness, and at less than a hundred feet from the surface.

The following is a record of a boring made at Chapin, on the county line between Scott and Cass counties:

		Ft.	In
No. 1.	Soil and drift clays	51	
No. 2.	Clay shale	6	
No. 3.	Sandstone	23	
No. 4.	Brown shale	14	6
No. 5.	Sandstone	14	6
No. 6.	Dark shale	6	
No. 7.	Sulphur rock	0	9
No. 8.	Clay shale	17	
No. 9.	Sulphur rock	0	4
No. 10.	Fossiliferous limestone	1	
No. 11.	Hard black slate	3	
No. 12.	Coal	2	
No. 13.	Fire-clay	3	
No. 14.	Limestone	1	
No. 15.	Clay shale	3	
No. 16.	Blue limestone	4	9
No. 17.	Fire-clay	7	
No. 18.	Sandstone	4	
No. 19.	Gray shale	7	6
No. 20.	Hard sandstone	3	
No. 21.	Sulphur rock and coal	2	2
No. 22.	Gray limestone	3	
No. 23.	Coal and black shale	1	9
No. 24.	Gray limestone	2	6
No. 25.	Conglomerate	1	9
No. 26.	Gray limestone	2	6
	Total depth	186	

A shaft was sunk to the first coal, No. 12 of the record, but it proved to be an unproductive seam, and the experiment was soon abandoned. It is probably the same as the Neeleyville coal, but it is only about half as thick here as it is at Neeleyville, two miles further west.

A shaft was commenced by Mr. Loy, at Edgewood, in Effingham county, and when last reported on was down nearly to the base of the upper Coal Measures, and as it was commenced above coal No. 16, the highest seam in the State of any practical value, the record is very interesting as showing the regular developments of these upper seams in the centre of the basin. For the following record I am indebted to Dr. G. W. Bassett, of Vandalia:

EDGEWOOD SHAFT.

		Ft.	In.
No. 1.	Soil, clay, sand and gravel	59	6
No. 2.	Rotten sandstone	1	
No. 3.	Yellow clay shale	3	
No. 4.	Red sandy shale	2	
No. 5.	Gray shale	16	6
No. 6.	Gray limestone	3	
No. 7.	Coal No. 16	0	5
No. 8.	Blue shale	3	
No. 9.	Sandstone and sandy shale	13	
No. 10.	Dark clay shale	20	
No. 11.	Impure fire-clay	6	
No. 12.	Hard calc. sandstone	3	
No. 13.	Gray sandy shale	8	
No. 14.	Clay shale, bottom dark	10	
No. 15.	Coal smut	0	4
No. 16.	Pebbly limestone and iron stone	3	
No. 17.	Dark sandy shale	30	
No. 18.	Dark shale with limestone bands	11	3
No. 19.	Coal (semi-block) No. 15	0	10
No. 20.	Fire-clay, with nodules of limestone	3	
No. 21.	Calcareous sand or limestone	8	
No. 22.	Blue shale	30	
No. 23.	Dark gray shale	30	
No. 24.	Dark and fawn-colored fossiliferous shales	40	
No. 25.	Bituminous shale, with shells and crinoids	1	
No. 26.	Coal, upper part cannel—No. 14	2	4
No. 27.	Dark gray fire-clay	3	
No. 28.	Sandstone and sandy shale	18	
No. 29.	Dark blue shale	6	
No. 30.	Dark and fawn-colored shale	12	
No. 31.	Coal (semi-block) No. 13	1	10
No. 32.	Fire-clay, with *sigillaria*, etc.	1	
No. 33.	Dark sandy shale	12	
No. 34.	Dark and fawn-colored shales	27	
No. 35.	Black bituminous limestone (fossiliferous)	3	
No. 36.	Coal No. 12	1	2
No. 37.	Fire-clay	2	
No. 38.	Dark gray shale, with one inch coal	5	1
No. 39.	Fire-clay	1	6
No. 40.	Hard sand rock	3	
No. 41.	Black sandy shale	5	

No. 42.	Hard sand-stone	3	
No. 43.	Very dark shale	9	
No. 44.	Limestone	4	
No. 45.	Jointed fire-clay	4	
No. 46.	Limestone	3	
No. 47.	Jointed fire clay	1	6
No. 48.	Black clod—Coal No. 11	1	
No. 49.	Limestone	2	
No. 50.	Jointed fire-clay	3	
No. 51.	Limestone	1	6
No. 52.	Bituminous shale	1	
No. 53.	Dark gray shale, with plants	6	
No. 54.	Sandstone, with salt-water	23	
No. 55.	Dark gray shale	3	
No. 56.	Conglomerate limestone	1	
No. 57.	Rash coal—Coal No. 10	0	8
No. 58.	Black clod	2	
No. 59.	Limestone, partly concretionary	4	
No. 60.	Black shale	1	6
	Total depth	483	11

This shaft terminates apparently not very far above the horizon of the Shoal Creek limestone, which lays about 385 feet above the coal in the shafts at Sandoval and Centralia, the nearest points where any of the lower coals have been opened, and it would have to be sunk about 400 feet further to reach a coal seam of any practical value for deep mining.

BUILDING STONE.

Many valuable quarries of building stone have been opened in this State since the publication of the preceding volumes, but from the press of other duties, I was not able to give as much time to their examination as was necessary to enable me to report fully upon them.

The location of the Southern Penitentiary at Chester has resulted in the development of a very important industry, in connection with the extensive beds of limestone and sandstone which had long been known to occur at that locality, but had remained comparatively useless for the want of the labor and capital necessary for their full development.

That division of the lower Carboniferous formation known as the "Chester Group" comprises several beds of limestone, sandstone and shale, and it is upon the lower part of this formation that the city of Chester and the Southern Penitentiary are situated. The following section will show the relative position and thickness of the rocks exposed on the Penitentiary grounds:

	Ft.
Massive brown sandstone, exposed	25
Limestone and shale, partly exposed	50
Green and blue argillaceous shales, mostly beneath a covered slope	70
Massive gray sandstone, with partings of green and blue shales, exposed	80

The prison buildings and yard are located on the lower limestone of the foregoing section, which is probably more than a hundred feet in thickness, and extends below the low-water level of the river, and to the height of sixty to eighty feet above low-water mark. The quarry in the prison yard has a perpendicular face of about forty feet of solid limestone in beds from one to four feet in thickness, and presents considerable variety of color and texture. Its prevailing color is a light gray, passing sometimes into buff, and again into a dark bluish-gray. The rock is sufficiently compact to receive a high polish, and some of the beds would make a handsome marble. The upper part of the bed is semi-oolitic in structure, while other portions are almost entirely made up of minute *bryozoans*, and the other low forms of organic life.

These quarries afford material adapted to all the ordinary uses to which limestones are usually applied, and from the favorable location of this institution on the Lower Mississippi, with uninterrupted navigation at nearly all seasons to all southern points, and with transportation by railroad to the interior towns where building stone of good quality is always in demand, a ready market will be found for all the varieties of building stone which the prison quarries can supply.

Dimension stone of almost any desirable size may be obtained here, and the foundation stone for the monument to be erected at Chester to the memory of Gov. Bond had just been completed, and was awaiting transportation to the cemetery at the time of my last visit to this locality. This was a single stone, 7½ by 7¾ feet square, and 30 inches thick, and estimated to weigh about 12 tons.

The prison buildings are mainly constructed of a fine brown sandstone, obtained from the upper bed of the foregoing section. The quarries from which this rock was obtained are about half a mile north of the penitentiary, but on the lands belonging to the institution. The quarries present a perpendicular face of about 25 feet of evenly-bedded brown sandstone, the beds varying in thickness from four inches to four feet or more. It breaks evenly across the lines of bedding, and blocks of any desirable size can be readily obtained. When freshly quarried the rock is soft, and can be easily dressed, but it hardens on exposure, and forms a handsome and durable stone for massive buildings. The supply of both sandstone and limestone is practically inexhaustible.

At Evansville, on the Okaw river, a fine quarry of excellent limestone has been opened, and a large amount of rock for the abutments of a suspension bridge has been taken out. The quarries are located about half a mile back from the river, and a hundred feet or more above low-water mark. The rock is a massive light-gray semi-oolitic limestone, and is the highest bed outcropping in the vicinity of the town.

The principal quarry shows a perpendicular face of about 15 feet of massive grayish-drab colored limestone, that closely resembles some of the semi-oolitic beds of the St. Louis group. Some of the beds attain a thickness of four or five feet, and will furnish dimension stone of any desirable size.

No characteristic fossils were found in it, but it was underlaid by nearly a hundred feet of shales and thin-bedded limestones, filled with the characteristic fossils of the Chester group, leaving no doubt in regard to the formation to which it belongs. It may, perhaps, be the equivalent of the regularly-bedded portion of the upper limestone in the Chester bluffs. The surface over which it forms the bed rock is considerably broken by sink holes, similar to, but smaller than those which prevail where the St. Louis limestone is the underlying rock. Should a railroad be constructed through this part of Randolph county, these quarries would become a source of profit to the owners, and would add an important item to the business of the road.

Rockville Quarries.—Two miles and a half west of Seville, in Fulton county, extensive quarries have been opened since the report on that county was published, in a sandstone overlying No. 2, and outcropping in the bluffs of a small stream running into Spoon river. These quarries are owned by Robert F. Leeman, of Cincinnati, who has erected machinery for manufacturing grindstones, whetstones, scythestones, and also for supplying dimension stone to the Wabash road and the towns on its route. The rock in the quarry shows a perpendicular face of about 20 feet, and furnishes dimension stone from two to three feet in thickness, and as large as can be conveniently handled.

The best grindstone grit comes from near the middle of the bed, and the stones manufactured here range from two to four feet or more in diameter. The rock has a sharp grit, and seems to possess an even texture that makes the stones desirable for ordinary use.

These quarries employ about 30 men, and being located immediately upon the railroad, the product can be readily shipped to any point where a market can be found.

The bottom of the quarry furnishes the best dimension stone, especially where it is required to withstand the action of frost and water. Its power of resistance is said to equal any sandstone yet found in the State.

At Marietta siding, about a mile further west, another quarry has been opened, but little work except stripping has been done. It is located on the same sandstone as the Rockville quarries.

COAL OIL.

The Litchfield Coal Company made a boring in the bottom of their coal shaft in November, 1879, for the purpose of determining whether another coal seam thick enough to be profitably mined, could be found below the one they were then working, and at the depth of 682 feet below the surface, and 255 below the coal in their shaft, they found the first deposit of coal oil of any value that has been found in the State. It is a heavy lubricating oil, and was associated with salt water and gas, the latter in such quantity that it might be utilized for lighting the city. For the following record of the beds passed through at Litchfield to reach this oil deposit, I am indebted to the Secretary of the Litchfield Coal Company.

		Ft.	In.
No. 1.	Surface clay, gravel, etc	75	6
No. 2.	Limestone	14	
No. 3.	Black slate and coal	3	6
No. 4.	Fire clay	4	
No. 5.	Clay shale	8	
No. 6.	Shelly limestone	5	
No. 7.	Shale and gray slate	79	
No. 8.	Hard, silicious rock	3	6
No. 9.	Fire-clay	2	
No. 10.	Shelly limestone	8	
No. 11.	Brown silicious rock, very hard	6	
No. 12.	Soft clay shale	3	6
No. 13.	Gray shale and sandstone	14	
No. 14.	Brown sandy shale	19	
No. 15.	Sandstone and shale	97	
No. 16.	Gray shale	45	
No. 17.	Dark shale	33	
No. 18.	Black shale	7	
No. 19.	Coal—No. 5?	0	2
No. 20.	Hard fire-clay	16	
No. 21.	Hard silicious rock	1	6
No. 22.	Coarse brown sandstone	9	

		Ft.	In.
No. 23.	Brown shale	10	
No. 24.	Gray slate	14	
No. 25.	Slate and shale	8	
No. 26.	Shale and sandstone	23	
No. 27.	Sandstone	9	
No. 28.	Coal (Litchfield seam)—No. 2?	4	
No. 29.	Gray slate and sandy shale	50	
No. 30.	Coal—Upper division of No. 1	2	6
No. 31.	Clay shale and fire-clay	5	6
No. 32.	Coal—Lower division of No. 1	2	4
No. 33.	Sandstone and shale	90	
No. 34.	Brown sandy shale	10	
No. 35.	White sandstone, with strong flow of brine and oil	13	
	Total depth	695	7

When I visited this locality in October, 1882, there were four wells in operation, producing about two barrels of crude oil per day each. The product is a heavy lubricating oil, worth considerably more in the market than the common petroleum. It comes, apparently, from about the base of the Coal Measure Conglomerate, or possibly from one of the Upper Chester sandstones.

Nothing definite is known as to the extent of the area over which this oil basin extends, as no boring has been made in the county deep enough to reach the oil-bearing strata, except in the immediate vicinity of Litchfield. The well commenced at Irving some months ago may throw some light on this question if carried to the depth of 1,000 feet, which I understand to be the requirement of the original contract.

SALT WELLS.

After the publication of the report on Perry county, a boring was made at St. Johns, for the purpose, mainly, of determining whether there was a coal seam of any practical value below the DuQuoin coal. At the depth of 970 feet a sandstone saturated with salt water was reached, that extended to the depth of 1,050 feet, the brine rising to various heights from 150 to 250 feet below the surface. There are now six wells in operation here, with a flow of about 16 gallons per minute to each well. The present yield of merchantable salt at these works is stated at 3,500 barrels per annum, and the product is manufactured into the various grades of salt in common use. No record of the boring could be obtained, but two thin coals were reported as occurrring below the DuQuoin seam.

NOTES ON LA SALLE COUNTY.

LaSalle is one of the most interesting counties in the State, not only from the variety and economic value of its mineral resources, but also from the peculiar geological phenomena that are presented within its borders. Situated on the northern confines of the great coal field of Illinois, its coal products find a ready market in the more northerly portions of this and the adjoining States of Wisconsin and Minnesota, where no productive coal beds have hitherto been found, and its favorable position in regard to the iron and zinc deposits of the northwest makes this county an eligible location for the economical reduction of these metallic products.

Among the economical resources of this county, bituminous coal ranks first in importance, and is found underlying nearly all that portion of the county lying south of the Illinois river, as well as a limited area north of that stream. Four coal seams, of sufficient thickness to be of practical value in the production of coal, outcrop within the limits of the county, and are the representatives of coals numbered 2, 4, 5 and 7 of the general section of the Coal Measures of this State.

Their aggregate thickness is about sixteen feet, and their range from two to seven feet, and they will be described further on in indicating the localities where they are worked.

An anticlinal axis crosses this county from northwest to southeast, having its center in the valley of the Illinois river, about three miles east of the city of LaSalle, where the Lower Magnesian limestone of Owen, the oldest rock in the State, is elevated above the surface to the height of about 80 feet. The Lower Carboniferous, Devonian and Upper Silurian formations are all absent in this portion of the State, so that the Coal Measures in LaSalle county overlie, unconformably, both the Trenton limestone and St. Peters sandstone of the Lower Silurian series.

The exposure of the Lower Magnesian limestone is restricted to a limlted area in the valley of the Illinois, its outcrop only extending eastward from Split-rock [about two miles. It affords the best hydraulic limestone in the State, and the manufacture of hydraulic cement has been an important industry at Utica for many years.

The St. Peters sandstone, which immediately overlays the Lower Magnesian limestone, forms the main portion of the river bluffs from near Utica to a point two or three miles east of Ottawa, and on Fox river from its mouth to the vicinity of Indian Creek, a distance of about ten miles. This sandstone will furnish an inexhaustible supply of the best glass sand to be found in the Mississiypi Valley, and in its economical importance it is second only to the Coal Measures in the value of its products. It is found at only two points in the State outside of LaSalle county, viz: at Grand de Tour, in Lee, and at *Cap au Gres* in Calhoun, counties. Its maximum thickness is probably about 225 feet in the southern part of this county, but it thins out to the northward, so that in the northern portion it does not much exceed 150 feet. Its extensive outcrops in the bluffs of the Illinois river make its economical products easily accessible to both railroad and water transportation, and the abundance of coal to be obtained in close proximity to this sandstone indicates that this is one of the most favorable points in the State, or in the United States, for the manufacture of all kinds of glassware, and several extensive factories of this kind have already been established in this county.

The Trenton limestone, which is the next formation above the St. Peter's sandstone, has been so much eroded where it appears in natural outcrops in this county, that no accurate estimate of its original thickness could be made from an examination of its surface exposures, but in boring at Streator for artesian water, its thickness was found to be a little over 200 feet, which is not more than half its average thickness in other portions of the State, where it has not been subjected to erosion. The outcrops only show the presence of from 25 to 75 feet of the lower part of the formation, the remainder, with the overlying Upper Silurian strata which were probably deposited over this portion of the State, have been removed by the long-continued eroding agencies which immediately preceded the Upper Carboniferous era.

The Trenton limestone affords some good building stone, and some of the layers take a good polish, and make a handsome marble. Usually it has too large a per cent. of alumina and magnesia to make a good material for the lime-kiln.

Clays suitable for brick, pottery and drain tile are abundant, and some of the fire-clays of the lower Coal Measures seem to be adapted to the manufacture of fire-brick.

Coal is by far the most important and valuable mineral product of LaSalle county, and its favorable position on the extreme northern border of the productive coal field enhances the value of this product, both for consumption in manufacturing establishments at home, and for export to the north, where no coal is to be found either in this or adjacent States.

The local examinations made during the past year were mainly confined to the southern half of the county, and were especially directed to the determination of the number, thickness and relative value of the coal seams to be found within its borders.

The axis of disturbance which has already been mentioned as crossing the county from northwest to southeast, follows the course of the Vermilion river from its mouth to the Livingston county line, and probably beyond, and has produced a marked irregularity in the distribution of the productive coal seams, and rendered their determination somewhat more difficult than would be the case if the beds had remained in their normal position.

North of the Illinois river, and east of this axis, no productive mines have been opened, except on the outcrop of the lower seam, where it has been worked to a limited extent for a local supply, nor is it probable that any extensive coal mines will ever be opened in that part of the county, although there is a considerable area there that is underlaid by thin outliers of the lower Coal Measures.

South of the Illinois, and east of the Vermilion, there is quite an extensive area underlaid in part by three productive coal seams, though, so far as I was able to determine, not more than two of these could be found at the same locality. At Lowell the Vermilion river flows over massive beds of Trenton limestone, and this forms the lower portion of the river bluffs, extending on the west side to the height of twenty feet or more above the river. The limestone is here directly overlaid by the Coal Measures fifty feet or more in thickness, showing the following section:

		Feet.
No. 1.	Sandstone partially exposed	8 to 10
No. 2.	Shale, with bands of Septaria	10 to 12
No. 3.	Black sheety shale	2 to 3
No. 4.	Clay shale	6 to 8
No. 5.	Coal No. 4	3
No. 6.	Green and purple shales	8 to 10
No. 7.	Trenton Limestone	15 to 20

The sandstone at the top of the foregoing section was only exposed in the top of the bluff about half a mile below the bridge at Lowell, and is probably the same sandstone which underlies the Streator coal at points further up the river. A band of limestone occurs somewhere in the bluff at this point, composed mainly of crinoidal stems about half an inch in diameter, a specimen of which was found here by the Hon. Elmer Baldwin. I did not find it in place, but it probably belongs somewhere in No. 2 of the foregoing section. It was only some three or four inches in thickness. No. 3 of the section I am inclined to regard as the representative of coal No. 5, and a thin coal occurs with it at some other points on the northeastern borders of the coal field. This would make the coal below it the representative of coal No. 4 of the general section, and further evidence in favor of this conclusion will be given further on. The quality of the coal obtained in the vicinity of Lowell is inferior to that obtained from the Streator seam, and also much inferior to that afforded by the lower seam in the shafts at Peru and LaSalle, which of itself is an indication that the Lowell coal is not identical with that.

On Sec. 24, T. 32, R. 2, the section observed was similar to that at Lowell, with the exception of the Trenton limestone, which is here at least 30 or 40 feet below the river level, the intervening space being occupied by the lower beds of the Coal Measures, which apparently thin out in a northerly direction before reaching that point. The section here is as follows:

		Feet.
No. 1.	Sandstone	10 to 12
No. 2.	Shale	6 to 12
No. 3.	Black slate	2
No. 4.	Shale and argillaceous limestone	4
No. 5.	Black slate, with rock bands	6
No. 6.	Clay shales	15 to 20
No. 7.	Covered space	4 to 5
No. 8.	Coal in river bed	1½ to 2

Forty-seven feet below the base of the foregoing section another seam of coal, 30 inches thick, was found by boring at this point, which I have no doubt is coal No. 2 of the general section, and the lowest seam in the shafts at LaSalle and Peru.

At Patterson's shaft, on Sec. 31, T. 32, R. 3, this lower seam is worked, and it affords a clean, hard, bright coal, about 3 feet thick, overlaid by a dove-colored clay shale, quite unlike any beds outcropping on the Vermilion, either above or below this point. Coal No. 4 appears to have thinned out toward the south before reaching this point, while No. 2 and the accompanying strata thin out in the opposite direction, so that there is no representative of the coal or the shale above it in the vicinity of Lowell.

At Kirkpatrick's ford, on the Vermilion, we met with the first outcrop of the Streator coal, in ascending that stream. The section at this point is as follows:

		Feet.
No. 1.	Bituminous shale	10
No. 2.	Coal (Streator seam)	8 to 9
No. 3.	Shale and fire-clay	10
No. 4.	Black shale	4
No. 5.	Sandstone and sandy shale	15 to 20

The coal in Patterson's shaft is about 80 or 90 feet below the Streator seam, and the space between the sandstone at the base of the foregoing section and coal No. 2 is mainly occupied by argillaceous and bituminous shales, with one or more bands of hard, impure limestone. No record of the Patterson shaft was kept, and no exposure was found where a detailed section from coal No. 2 to the sandstone under the Streator coal could be made.

As coals No. 2 and 4 are nowhere exposed at the same point on the Vermilion, a superficial examination might lead to the conclusion that they were not distinct seams, but the difference in the quality of the coal they afford, and in the character of the roof shales, and moreover the presence of both seams on Sec. 24, T. 32, R. 2, where a boring was made to demonstrate the presence of the lower seam, leaves no room to doubt the separate position which they occupy. Hence we are justified in the conclusion that there are three coals outcropping on the Vermilion, all of which are worked at the present time; No. 2 in the shaft at Patterson's, No. 4 in the vicinity of Lowell, and No. 7 at Kirkpatrick's ford, and in the vicinity of Streator.

Some diversity of opinion has existed with those who have given special attention to the geology of this county, in regard to the position which the Streator coal occupies in the general section of the coal strata of this State, but from a careful examination of all the outcrops of the seam from Kirkpatrick's ford, to the last point where it appears above the river level above Streator, I am fully satisfied that it is the exact equivalent of coal No. 7 of the general section. The coal which it affords is perhaps rather better in quality than that hitherto obtained from the upper seam in the shafts about Peru and LaSalle, but it has been generally neglected in all the shafts where Nos. 2 and 5 are found, and therefore its average quality at those points has not been fairly determined. It ranges in thickness from 5 to 8 feet, with an average of about 6 feet, and it probably affords as much coal at the present time as No. 5, which is the next in average thickness, and the one most extensively mined in the central part of the county.

In the vicinity of Brock's ford, two miles south of Streator, a limestone occurs near the top of the bluff, that closely resembles the limestone south of Petersburg, in Menard county, which there lies some 25 to 30 feet above coal No. 7, and it contains a similar group of fossils. In addition to this, the shales below the Streator coal contain ironstone concretions, completely filled with the little crustacean figured, and described in a preceding volume under the name of *Leaia tricarinata*, which is regarded as a characteristic fossil of the shales under coal No. 7, from whence it has been obtained at several localities in the State. The following section shows the strata to be seen in the bluffs of the Vermilion, between Brock's ford and Streator.

		Feet.	In.
No. 1.	Light gray compact limestone	4	
No. 2.	Blue sandy shales and soft sandstone, with concretions of sandy iron ore	35	
No. 3.	Bituminous shale	0 to 2	
No. 4.	Coal No. 7	5 to 7	
No. 5.	Shale with discoidal concretions of iron ore	6 to 8	
No. 6.	Fire-clay	2 to 2	6
No. 7.	Hard concretionary sandstone	12 to 15	
No. 8.	Shaly sandstone, extending below the river level, exposed	20 to 25	

The limestone at the top of the section contains several species of small *Brachiopods*, the most common being *Athyris subtilita*, *Spirifer lineatus*, *Terebratula bovidens*, and a small *Naticopsis*, or *Trachydomia*, which were mostly in the form of casts, the pustulose shell being removed.

The hard sandstone, No. 7 of the section, will make a durable stone for rough walls where strength is the main requisite.

Between Streator and the mouth of Prairie creek, the sandstone under the Streator coal rises so as to form with the sandy shales below, a perpendicular cliff about forty feet in height. Over this sandstone ridge the coal has been carried away by the denuding agencies of the Drift period, but a short distance away from the river it comes in again immediately below the drift. Near the mouth of the creek the sandstone becomes thinner, and the coal appears above it and slopes rapidly down to the river level.

Several borings have been made in the vicinity of Streator, to the horizon of coal No. 2, but I was unable to obtain any reliable record of the strata passed through. I was informed, however, that the distance between the two seams was about 80 feet. The quality of the coal afforded by No. 2 is generally superior to that of any of the higher seams, but it seldom exceeds a thickness of 3 or 4 feet, and lying deeper below the surface, and consequently requiring a larger investment of capital to reach it, it has generally been neglected where the upper seams were developed. In McDonough county, where its average thickness scarcely exceeds two feet, it has furnished the main supply of coal for the city of Quincy, including the river trade at that point for the past twenty-five years, and will no doubt continue to do so for at least another decade.

The aggregate thickness of the Coal Measures on the east side of the axis, heretofore mentioned, probably does not much exceed 200 feet, and the distance between coals No. 2 and 7 is about 80 feet, while on the west side the distance between these coals is about 200 feet, and the entire thickness of the Coal Measures may be estimated at over 600 feet. This variation in the thickness of this formation is probably in part due to the rapid thinning out of the beds towards the eastern border of the coal field, and in part to erosion which has carried away on the eastern side nearly all the strata above the horizon of No. 7 coal.

The details of the following section of the Union Coal company's shaft, at LaSalle, was furnished by Mr. Chas. J. Devlin, the acting Secretary of the company. This shaft is located in the south part of the city, and commences below the main limestones that outcrop along the river bluffs from LaSalle to Peru.

		Ft.	In.
No. 1.	Clay shale	11	
No. 2.	Brown shale	11	
No. 3.	Coal	1	
No. 4.	Brown shale	20	
No. 5.	Hard limestone	3	
No. 6.	Shale	10	
No. 7.	Rock	1	
No. 8.	Shale	12	
No. 9.	Fire-clay	6	
No. 10.	Rock	3	
No. 11.	Fire-clay	12	
No. 12.	Pebbly clay	4	6
No. 13.	Clay shale	10	6
No. 14.	Black slate	10	
No. 15.	Clay shale or fire-clay	15	
No. 16.	Coal, No. 7 (?)	4	
No. 17.	Fire-clay and clay shale	24	
No. 18.	Sandstone	2	
No. 19.	Black shale	13	
No. 20.	Coal, No. 5	5	
No. 21.	Clay shale	60	
No. 22.	Limestone	5	
No. 23.	Shale, with some limestone	71	
No. 24.	Dove colored shale	12	
No. 25.	Coal, No. 2	4	
	Total depth	330	

I refer No. 16 in this shaft to the horizon of coal No. 7, mainly from its stratigraphical position, but it is not impossible that it may represent No. 6 instead. No fossels were found in connection with it, at the only outcrop of the seam I was enabled to examine, and hence its stratigraphical position is the only evidence that was available for its identification. The outcrop of this coal was found in a deep ravine, just below the uplift at Split Rock, where an opening had been made to procure the potter's clay, which forms a heavy bed immediately below the coal.

Two miles and a half north of La Salle, one of the deepest shafts in the county has been sunk by the Caledonia Coal Company, and the following details of it were kindly furnished by the pit boss, Mr. JOHN P. DUNCAN:

		Ft.	In.
No. 1.	Drift clay and gravel	13	
No. 2.	Green and purple shales, with thin bands of impure limestone and a thin coal seam	60	
No. 3.	Limestone, in two beds	27	
No. 4.	Blue, green and gray shales	215	
No. 5.	Black slate	8	
No. 6.	Coal No. 7 (?)	4	
No. 7.	Fire and potter's clay	16	
No. 8.	Clay shale	14	
No. 9.	Coal No. 5	3	6
No. 10.	Fire-clay	5	
No. 11.	Sandstone	5	
No. 12.	Clay shale	54	
No. 13.	Brown shale	90	
No. 14.	Black slate	2	
No. 15.	Sandstone	14	
No. 16.	Black slate	2	
No. 17.	Clay shale	14	
No. 18.	Coal No. 2	3	10
	Total depth	550	4

The lower seam is the one worked at the present time, in this shaft, and it is said to be underlaid here by a bed of excellent fire clay, from 12 to 14 feet in thickness. The coal which it affords is superior in quality to that from either of the upper seams.

The beds above the main limestones, No. 3 of the Caledonia shaft, were found well exposed, in the big cut on the Illinois Central railroad north of the zinc works, and the following is a detailed section of them as they appeared there:

		Feet.
No. 1.	Green and ash-gray clay shales	4
No. 2.	Nodular calcareous shale	3
No. 3.	Greenish clay shale	12 to 15
No. 4.	Impure chocolate-colored limestone	2
No. 5.	Red and green shales	10
No. 6.	Green, shaly clay	8

No.		Feet.
No. 7.	Nodular shale, or shaly limestone	6
No. 8.	Upper main limestone	12
No. 9.	Green shale	2
No. 10.	Lower limestone	10 to 12

These are the highest Coal Measure strata outcropping in the county, and they have been referred by some observers to the Permian age, but I was unable to find any satisfactory evidence of unconformability between them and the limestone No. 8, on which they rest, and the fossils, so far as they have been determined, are of well-known Coal Measure forms.

The most common fossils in the calcareous shales and impure limestones of this horizon were the following species: *Orthis Pecosii, Chonetes Flemingi, Productus La Sallensis, Hemipronites crassa, Athyris subtilita,* all of which are characteristic Coal Measure forms. On the south side of the Illinois, these beds make their appearance in the cut of the Illinois Central railroad from the river bluff to a point half a mile or more beyond Oglesby, where the railroad grade finally ascends entirely above them and onto the overlying drift deposits.

The beds immediately below the main limestones are well exposed in the bluffs between La Salle and Peru, and there is a decided increase in the thickness of the shales as we recede from the axis of disturbance, already mentioned on a preceding page. On the Little Vermilion where it intersects the bluffs of the Illinois, the main limestones are separated by only about two feet of greenish-colored shales, but in descending the river bluffs toward Peru, the shale increases to a thickness of 8 or 10 feet. The following section was made along the river bluff in the vicinity of Peru:

No.		Ft.	In.
No. 1.	Upper limestone	10 to 12	
No. 2.	Green and purple shales	6 to 8	
No. 3.	Lower division of main limestone	6 to 8	
No. 4.	Bituminous shale	1	6
No. 5.	Gray, brown and green shales	8	
No. 6.	Impure coal	0	6
No. 7.	Gray and green shales	12 to 15	
No. 8.	Nodular limestone	4 to 5	
No. 9.	Green nodular shale	12 to 15	
No. 10.	Hard gray limestone	2 to 3	
No. 11.	Green shale (exposed)	2	
No. 12.	Unexposed to river level	15 to 20	

No. 1 of this section is the main quarry rock used as a building stone in LaSalle and Peru. It is a compact gray limestone, considerably stained with the oxide of iron, and resembles the limestone on Sugar Creek, in Sangamon county, used in the construction of the Old State House at Springfield.

The most characteristic fossils of this limestone are *Productus Nebrascensis*, *P. Prattenianus*, *P. punctatus*, *Spirifer cameratus*, *Athyris subtilita*, *Pinna per-acuta*, crinoidal joints, and, rarely, the body of a *Eupachycrinus* or *Poteriocrinus*. A few fish teeth and spines have also been obtained from this limestone.

The lower division of the limestone No. 3 of the foregoing section, which may be regarded as a distinct bed, is quite argillaceous and of but little value as a building stone. It is unevenly bedded, and the layers are separated by shaly partings, that are, at some points, completely filled with fossil shells. The fossils of this limestone are *Athyris subtilita*, *Terebratula bovidens*, *Spirifer cameratus*, *S. lineatus*, *Productus longispinus*, *Spiriferina Kentuckensis*, *Platyostoma Peoriense*, numerous corals not yet determined, and casts of *Pleurotomaria*, *Bellerophon and Nautilus* of several species.

I have been inclined to regard this limestone as the equivalent of that at Carlinville, which it resembles, both in its lithological characters and in the specific character of its embedded fossils. If so, it represents the horizon of No. 9 coal, and is the dividing line between the upper and lower Coal Measures. It is rather more argillaceous here than in Macoupin county, but otherwise it bears a close resemblance to that rock, and its position is about where that limestone, if present here, should be found.

On the south side of the Illinois river there are two or three coal shafts in operation, only one of which had any record of the beds passed through. The Oglesby shaft furnished me the following section:

		Ft.	In.
No, 1.	Drift clay and gravel	30	
No. 2.	Limestone, in two beds	25	
No. 3,	Shale	7	6
No. 4.	Coal	0	2
No. 5.	Shale	7	6
No. 6.	Hard red rock	4	6
No. 7.	Shale	8	7
No. 8.	Sanpstone	4	11
No. 9.	Red shale	13	11
No. 10.	Gray shale	9	2
No. 11.	Limestone	3	6
No. 12.	Shale	19	6
No. 13.	Hard rock	2	6
No. 14.	Shale	39	
No. 15.	Sandstone	14	6
No. 16.	Shale	50	
No. 17.	Black slate	18	7
No. 18.	Coal—No. 7?	3	6

		Ft.	In.
No. 19.	Fire-clay and shale	50	
No. 20.	Coal—No. 5	5	
No. 21.	Fire-clay	3	9
No. 22.	Sandstone	5	4
No. 23.	Dark red shale	2	6
No. 24.	Sandstone and sandy shale	42	11
No. 25.	Shale	71	
No. 26.	Gray clay shale	18	6
No. 27.	Coal No. 2	3	6
	Total depth	464	10

Both the lower seams are worked in this shaft, and they furnish all the coal mined in the vicinity of LaSalle or Peru at the present time, but it is quite probable that when a careful examination of the upper seam is made, it will be found to afford, at some points, a fair quality of coal. It is unquestionably the representative of either No. 6 or 7 of the general section, and both of them are extensively mined in other portions of the State.

Whether the Streator coal, and the upper seam in the shafts at LaSalle and vicinity, are identical, is a point I have been unable to decide with certainty, as no fossils were found associated with the latter at the only localiiy where its outcrop could be seen, and the associated strata afford no satisfactory evidence on this point.

The character of the deep-lying formations beneath the southern part of LaSalle county was fully determined by the artesian boring at Streator, and I am indebted to Dr. E. Evans for the following record of this well:

		Ft.
No. 1.	Drift-clay, sand and gravel	30
No. 2.	Coal Measures	211
No. 3.	Trenton limestone	203
No. 4.	St. Peters sandstone	225
No. 5.	White limestone	90
No. 6.	White sandstone	133
No. 7.	White limestone	211
No. 8.	White sandstone	37
No. 9.	Dark gray limestone	50
No. 10.	Fine reddish sandstones	15
No. 11.	Dark gray limestone	13
No. 12.	White and brown sand	1
No. 13.	Gray limestone	18
No. 14.	White and brown sandstone	168
No. 15.	Blue shale	100
No. 16.	Dark limestone	73
No. 17.	Variegated sandstone	187
No. 18.	Soft limestone	60
No. 19.	Variegated seales	158
No. 20.	Dark red sandstone	80
No. 21.	Blue shale	50
No. 22.	Bluish, drab and buff limestone	383
	Total depth	2,496

—4

Nos. 5, 6, 7 and 8 should probably be included in the Calciferous group, while all below that may be referred to the Potsdam period, and this boring indicates a very rapid increase in thickness of both these formations in their southward extension, over what they attain in Wisconsin and Minnesota, where they form the surface rocks over extensive areas.

Peddicord's well, near Marseilles, was carried to the depth of 2,189 feet, but the flow of water was only one and a half barrels per hour, The following is a copy of the published record of this well:

		Ft.
No. 1.	Drift clay, gravel, etc	269
No. 2.	Clay shale	65
No. 3.	Limestone	25
No. 4.	St. Peters sandstone	290
No. 5.	Calciferous	? 617
No. 6.	White sandstone	262
No. 7.	Limestone	52
No. 8.	Shale	115
No. 9.	Slate	112
No. 10.	Shale	9
No. 11.	Limestone	29
No. 12.	Sandstone	298
No. 13.	Limestone	46
	Total depth	2,189

The principal flow of water was from No. 12, and it rose within 16 feet of the surface until the well was tubed, when it overflowed the surface, yielding about 36 barrels per day. The quality of the water is not given. No. 5 is described in the published section as Calciferous, but it probably includes nearly or quite 200 feet that properly belongs to the Potsdam period. The similarity in the lithological character of the beds composing these two groups is such that it is impossible to determine, from the material brought up from an ordinary boring, where the stratum belongs, and the thickness of the Calciferous must be determined by its general average at other localities.

The St. Peters sandstone, and the white sandstone of the Calciferous group, were both found to be water-bearing in the Streator well, the water from the St. Peters coming within 40 feet of the surface, and that from the Calciferous within about 34 feet, and the water was reported to be sweet and apparently free from deleterious mineral substances. The water from the Potsdam was brackish and unfit for common use, but rose in a tube to the height of 45 feet above the surface.

The location of this well is 40 feet above Lake Michigan and 618 feet above sea level.

The surface deposits of LaSalle county will furnish an inexhaustible supply of sand, clay and gravel. The sand pit in the vicinity of Streator furnishes a clean, sharp sand, that is shipped in large quantities by railroad wherever a market can be found. The following section may be seen at this pit:

	Ft.
Brown clay	4
Ash-colored clay	4
Sand, with streaks of fine gravel	20
Coarse gravel	7

The clay used in making tile at Streator comes from the bottom of what were formerly shallow surface ponds, that have been filled up mainly by the wash from the higher grounds by which they were surrounded. It is a tough, fine, unctious clay, and at some points is found as much as ten or twelve feet in thickness. It is evidently more modern than the brown clay of the Drift period, and overlays that deposit when both are present. The growth and decay of aquatic grasses, that usually abound in shallow ponds, produce a fine silicious sediment, and this, with the wash from the higher grounds adjacent to them, will fairly account for the occurrence of these tough clays in this position. In other portions of the county the brown clay of the Drift, or, more properly speaking, of the *loess*, is used in the tile factories with satisfactory results.

In closing these brief notes on the geology of LaSalle county, I desire to express my obligations to Dr. E. Evans, of Streator, for valuable information in regard to the geology of that part of the county, and for hospitable entertainment, and transportation to such localities on the Vermilion river as it seemed desirable to visit; and also to the Hon. Elmer Brldwin for similar favors while exploring the outcrop on the river in the vicinity of Farm Ridge; and also to Mr. John B. Duncan, of the Caledonia shaft, Mr. Chas. J. Devlin, of the Union, and the proprietors of the Oglesby shaft, for a detailed record of their works.

It is to be regretted that a detailed record of every coal shaft is not kept, for such records would be of great value, not only to the proprietors and managers of the mines, but to all who desire to obtain reliable information in regard to the value and extent of our coal resources.

PART II.

PALÆONTOLOGY OF ILLINOIS.

SECTION I.

DESCRIPTIONS OF FOSSIL VERTEBRATES.

By ORESTES ST. JOHN and A. H. WORTHEN.

DESCRIPTIONS OF FOSSIL FISHES.

A Partial Revision of the Cochliodonts and Psammodonts; Including Notices of Miscellaneous Material Acquired from the Carboniferous Formations of the United States.

By ORESTES ST. JOHN and A. H. WORTHEN.

INTRODUCTORY.

The present work is largely though not exclusively concerned with the consideration of those distinctively carboniferous families of ancient Selachians, the Cochliodontidæ and the Psammodontidæ. Although in the majority of instances the classification now adopted has necessitated the amending, amplifying, and curtailment of the attributes ascribed to genera, it has not been deemed necessary to give a detailed diagnosis of all the genera thus revised. In the latter instances the descriptions of species will afford the necessary information relating to the peculiarities of the genera to which they belong, and a glance at the illustrations will often convey a vivid impression of those distinctions.

It has been impossible to avoid repetition of details in the notices of the species, especially in the desire to render for each species a comprehensive diagnosis by itself; otherwise the descriptions would mainly consist of comparisons of their distinctive features as contrasted with one another, and we have deemed it the safer plan to err on the score of details rather than brevity, stating the facts concisely as possible, but omitting none of evident consequence as aids to a fair conprehension of their special characteristics and their resemblances and distinctions compared with allied species. In no similar investigation have so many and varied materials relating to these interesting groups of Selachians been brought forward for critical consideration at the same time. That the subject was somewhat involved may be readily understood by all students; but to none so much as to the specialist can the actual state of things in this relation be at all adequately appreciated. This has largely resulted from incomplete data, and to some extent also to the lack of familiarity with the association of forms in the same deposits. For it must be confessed that in the very few exceptions these remains have been considered individually, either the various *forms* have been interpreted as distinct species, or in some instances they have been regarded as the representatives of distinct genera. This has given rise to the establishment of generic groups which already we see the necessity of abandoning, while the specific forms are largely curtailed by their association into well-defined categories embracing two, three, and even four distinct forms, all pertaining to a single species. There can no longer remain a doubt as to the specific identity of the four forms which Messrs. Newberry and Worthen described under the head of *Cochliodus nobilis* (*Coch. latus*) of Dr. Leidy; and yet we are here furnished three groups formerly regarded as possessing generic importance, viz: *Cochliodus*, *Streblodus*, and *Helodus*, in part. The announcement of Professor Richard Owen of the discovery of a third mandibular form of *Cochliodus* (the precise nature of which, however, we are not familiar with) very likely will add a fifth form to those already noted under so-called generic heads as really belonging to the genus *Cochliodus*. Very nearly the same state of things obtains in relation to the genera *Deltodus*, *Sandalodus*, *Pœcilodus*, etc. Indeed the various forms of all these *Cochliodont* genera have very generally received specific designations, while some of them have been identified with genera widely differing from one another, as is the case with the forms herein noticed under the generic term *Orthopleurodus*.

While the facts elicited by the stratigraphical knowledge accompanying the greater part of the materials submitted to us have rendered possible, indeed necessitated the revision of the genera of the Cochliodonts, it has also developed interesting and important facts bearing on the derivation and relations of these genera. That these may be made comprehensible in briefest statement, the subjoined tabular review of the geological formations immediately concerned, may not be inadmissible in this place.

Table of Carboniferous formations, as developed in the region of the Upper Mississippi:

Upper Carboniferous	Upper Coal Measures.
	Lower Coal Measures.
Lower Carboniferous	Chester limestone.
	St. Louis limestone.
	Warsaw limestone.
	Keokuk limestone.
	Upper Burlington limestone.
	Lower Burlington limestone.
	Kinderhook beds.

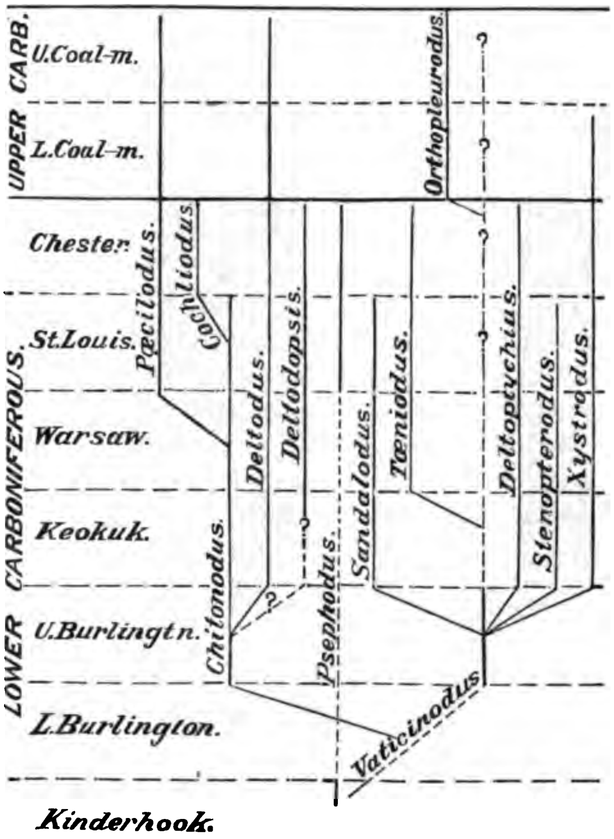
In the majority of cases the remains of fishes are found in definite, readily identifiable horizons, indeed chiefly in a limited stratum, where they are crowded together forming veritable bone-beds, though by no means thus restricted, as their remains are found more or less scattered in many formations. Yet the latter occurrences are, as might be expected, comparatively rare.

The earliest genus, *Psephodus*, whose relations with the more typical representatives of the family may be a matter of reasonable doubt, had its beginning in the oldest or Kinderhook formation, only ceasing in the latest or Chester epoch of the Lower Carboniferous period. Near the close of the Kinderhook epoch *Vaticinodus* was introduced, authentic representatives of which continued to exist during the Upper Burlington epoch. *Tæniodus*, whose relations seem to be nearest *Psephodus* of all the true Cochliodonts, is first met with in the Keokuk formation, continuing thence into the Chester, where it is last seen. During the Upper Burlington epoch *Deltoptychius* was introduced, which appears to be a modification of *Vaticinodus*, as is also *Stenopterodus*, which originated at the same time, and whose remains occur in each succeeding formation as late as the St. Louis, while *Deltoptychius* continued to exist during the deposition of the Chester limestone. In point of time, also, *Sandalodus* began contemporaneously with the latter genera, with which its affinities appear to be most intimate, although it presents a more marked modification of generic characteristics than those distinguishing the three last named genera, one from the other. In *Orthopleurodus* these modifications are carried to an extreme, as especially notable in the maxillary terminal form, though its mandibular terminal teeth are very similar to the homologous form of *Deltoptychius*, while the median form of the same jaw is intimately allied to that of *Sandalodus*. Pertaining to the same category are the forms of *Xystrodus*, and, perhaps, *Tomodus*, which apparently was the contemporary of the above mentioned genera, its remains being first encountered in the Upper Burlington, and only ceasing in the lower Coal Measures. It presents the simplest form of the group to which it especially pertains, and throughout its extensive vertical range or distribution in time, it maintains its distinctive peculiarities with remarkable persistency.

Considering the more typical representatives of the family, the earliest to appear is *Chitonodus*, which began during the Lower Burlington epoch and is last met with in the St. Louis. It is clearly the forerunner of *Pœcilodus* and *Cochliodus*, which appeared at later epochs, and which are modifications based upon the same plan, and which might readily be supposed to possess features that entitle them to at least sub-family rank in contradistinction to the before-mentioned genera. While *Cochliodus* was apparently of comparatively brief duration, since its remains have thus far only been met with in the St. Louis and Chester formations, *Pœcilodus*, the earlier of the two to make its appearance, dates from the Warsaw, the last representative being derived from the upper Coal Measures. Throughout this vast geological range its species manifest the least tendency toward differentiation, on the contrary maintaining the distinctive characteristics of the genus with extraordinary fidelity to the type. The same may be said of *Deltodus*, whose inception is contemporary with *Chitonodus*, with which its relations are, perhaps, the most intimate. This is especially pronounced in the case of the homologous terminal forms of the mandible of either genus, *Deltodus* maintaining a simple convex anterior lobe in lieu of the median coronal prominence of *Chitonodus*, which is a mere modification of the former, and which reached its extreme differentiation in *Cochliodus*; but in the supposed terminal form of the upper jaw we are again presented with a marked departure from the *Cochliodus* type, the significance of which is sought in the previously mentioned genus *Sandalodus*, while a less intimate relationship with *Deltoptychius* and *Orthopleurodus* is noted, but sufficient to arrest attention with suggestions of their common origin. *Deltodopsis* evidently was a later modification of *Deltodus*, and, although it is a well defined group, it is not clear whether it should be deemed of greater rank than subgeneric.

The foregoing observations are rather what the comparatively meagre facts seem to suggest, than actual demonstrations of a complete system of derivation and generic relations. It is therefore with no small degree of trepidation we venture to exhibit these supposed relationships in diagramatic form; but it will at least subserve the purposes of illustrating in a vivid manner the stratigraphical range of the various generic groups alluded to.

DIAGRAM ILLUSTRATING THE STRATIGRAPHICAL DISTRIBUTION AND THE RELATIONS OF THE GENERA OF COCHLIODONTS.



Besides the above mentioned Cochliodonts and Psammodonts, a considerable number of heretofore undescribed forms, pertaining chiefly to Ichthyodorulites, or defensive spines, are noticed, being acquisitions acquired since the publication of the preceding volume of the Illinois Geological Survey. As in connection with the latter work the authors owe acknowledgment to the same gentlemen, who have not only contributed material, but have freely shared the results of their familiarity with the objects themselves, and the invaluable information relating to their stratigraphical association and distribution, so that we feel a double interest with them as contributors to a knowledge of these early vertebrates.

Besides the magnificent collections of Mr. Frank Springer and Mr. W. C. Van Horne, in the use of which we have enjoyed unrestricted liberties, we are indebted for valuable aids, which are duly acknowledged at the proper place in the accompanying text. Through the courtesy of Dr. Charles A. White, palæontologist of the U. S. Geological Survey, we have had access to the collections of the National Museum, which have been brought in by Government expeditions to the Territories. We are also under great obligations to Dr. Joseph Leidy, who kindly procured us the loan of valuable types belonging to the Museum of the Academy of Natural Science of Philadelphia. It affords us pleasure in rendering acknowledgments and our thanks to Lord Enniskillen and Dr. L. de Koninck, for valuable information in relation to the occurrences of Carboniferous fishes in Great Britain and Belgium. We are also specially indebted to Mr. Charles Wachsmuth, who has favored us with much additional material from the Kinderhook and Burlington formations. Similar favors have also been extended us by Mr. L. A. Cox, of Keokuk, Mr. Alexander Butters, formerly of Carlinville, and Dr. George Hambach, of St. Louis. We have also had the use of Mr. L. A. Fuller's collection, and Mr. A. S. Tiffany, of Davenport, has placed in our hands some very interesting material from various Carboniferous and Devonian formations. Professor I. C. White, of the Pennsylvania Geological Survey, has kindly furnished us material from the Lower Carboniferous fish-horizons, which he has discovered in Western Pennsylvania; but these last, we regret, we have been compelled to omit in the present work.

O. St. J. and A. H. W.

COCHLIODONTIDÆ, Owen.

GENUS PSEPHODUS, Agassiz.

Psephodus, Agassiz, MSS., 1859, etc.

The genus *Psephodus* was recognized by Professor Agassiz in 1859, by whom *Cochliodus magnus*, Ag., of the Irish Mountain limestone, was regarded as the typical species. This determination was accepted by British palæichthyologists, and a few years later, 1862, it was authoritatively published by Messrs. J. Morris and G. E. Roberts, in the Quat. Journ. of the Geol. Soc. of London, XVIII, p. 102. At a subsequent date, 1866, Messrs. Newberry and Worthen, in their investigations of the fossil fishes published in the report of the Illinois Geological Survey, Vol. 2, p. 92, described several congeneric species from the American Lower Carboniferous formations, however, evidently overlooking the prior published conclusions arrived at by Professor Agassiz, as they distinctly identify the type species of *Psephodus* with the American species, to which they applied the generic designation *Aspidodus*. In regard to the generic identity of the American species described under the latter designation, as also those additional ones herein first made known, with *Psephodus magnus*, Agass., there is not the least doubt.

In the present work the results of the attempts made to identify the probable complete dentition of *Psephodus* are omitted, only such forms receiving brief diagnostic notice, the relations of which may be considered as even more than probably determined. These consist of two distinct forms of heavy, more or less spirally in-rolled triturating or crushing plates, investing the median region of the rami of the jaws:

First, teeth presenting a trapezoidal outline, the crown traversed longitudinally by a low, obtuse-crested ridge, culminating posterior of the median line, the inner margin somewhat angularly rounded, outer extremity always truncate with channeled, crenulate articular surface, the lateral borders undulated as though for coadaptation with the lateral articular extremities of narrow serial teeth.

Second, teeth generally more obliquely trapezoidal in outline, in which the coronal ridge is relatively inconspicuous, and the inner margin gently arched, from which the lateral borders less rapidly converge towards the outer extremity, their articular surfaces also undulated. Coronal surface minutely punctate. The above forms are provisionally referred to opposed positions on the lower and upper jaws respectively, chiefly on account of the somewhat stronger resemblance of the first mentioned form with the contour of the mandibular teeth of typical Cochliodonts. With the above remains are associated narrow or transversely elongate teeth, whose crenulated edges and coronal contour clearly point to their intimate kinship with the preceding forms. The latter include the European form originally described under the term *Helodus planus*, Agass., which was by Capt. Jones regarded as belonging to *Psephodus magnus*. There are other similar forms more or less numerously represented in the collections, which may also prove to have been associated with those above noticed.

In reference to the dentition of *Psephodus* our information is still meagre, although the identity of a variety of seemingly widely diverse forms may be asserted with a degree of confidence. While certain conspicuous forms belonging to the genus may be compared with the dental elements met with in *Cochliodus*, there was unquestionably a marked contrast in the character of the combined dental armament of the jaws of those genera. Indeed, the resemblances between them are but little more intimate than obtains in the instance of *Cestracion* and *Cochliodus*. While the median portion of the rami of the jaws of *Psephodus* was enveloped by a moderately contorted dental plate, constituting its chief point of resemblance with *Cochliodus*, this plate was flanked on either side by series of teeth disposed in rows from within outward similar to the occurrence of the teeth upon the jaws of *Cestracion*. Therefore, the solid triturating plates of *Psephodus* are not strictly homologous with the large posterior teeth of *Cochliodus*, but they are more properly designated as "median" teeth of the rami of the jaws.

Not infrequently individuals of the median forms are met with which show one or more partially detached, laterally elongate teeth at the outer extremity of the plate, which is always abruptly truncated, leading to the inference that these median plates themselves were, in the earlier stages of development, made up of series of teeth. On the other hand, certain forms occur which have been noticed under various generic designations (*Desmiodus*, *Orodus*), which are composed of series of transverse coronal crests, firmly soldered into a continuous plate at the impingement of their bases, in which condition they bear a remarkable resemblance in outline and direction of inrollment, to the above mentioned median forms. But beyond deducing certain permissible conclusions bearing on the probable affinities of *Psephodus*, the meagre array of data is deemed insufficient to warrant, at the present time, the critical relegation of the diverse dental materials alluded to in this connection.

In American geölogical history, *Psephodus* was amongst the earliest representations of its order in the Lower Carboniferous period, its first occurrence dating from the Kinderhook epoch. Although the succeeding Burlington, Keokuk and Warsaw formations have as yet afforded no evidence of the presence of the remains of the genus (if we except the occasional appearance of *Helodus planus*-like forms), its forms are sparingly met with in the St. Louis deposits, and in the super-adjacent Chester division several forms, probably pertaining to a single species, are conspicuously prevalent. The various species occurring through so great an interval of time, ranging from the earliest to the latest epoch of the period, exhibit an extraordinary persistency of the type without parallel amongst the Cochliodonts, if we except the doubtful relations of the later introduced species provisionally identified with *Vaticinodus*. From this point of view the genus would appear to be prominently isolated so far as relates to precursor or subsequent derivatives. Of the former we have not even the vaguest intimation, and the latter, even under the most liberal interpretations, have undergone excessive differentiation. The presence, in the extreme anterior portion of the jaw of *Cochliodus*, of transverse coronal ridges, if not of isolated teeth, in series corresponding to those abaft and forward of the convolute median plate in *Psephodus*, offer tangible evidence of their probable origin, though their relations are less intimate than might be expected in groups almost coeval in their inception.

While it is not deemed improbable that the acquisition of more complete evidence may lead to the discovery of still more intimate relationship between *Psephodus* and typical Cochliodonts, the relations of the former with *Psammodus* are so remote as to preclude the inference, which has, however, found expression, that *Psephodus* constitutes a sort of transition connecting the Psammodonts with the Cochliodonts.

PSEPHODUS OBLIQUUS, St. J. and W.

Pl. I, Figs. 1, 2, 3, 4, 5.

Under the above term are included series of teeth represented in the collections by a number of individuals, which range themselves under two, perhaps three or more well-defined groups, distinguished by their outline and general conformation, and which, taken together, are not considered separable into so many distinct species; on the contrary, there exists strong presumptive evidence of their having constituted parts of the dentition of one and the same species.

Only the two most conspicuous forms are noticed in this place.

One of these forms is represented by teeth which possess the characteristics of what may be regarded the typical representative teeth of the genus *Psephodus*, comparable with the larger and more tumid teeth of *P. magnus*, Agass., distinguishable, however, by their more symmetrical and smaller size. In general outline convolutely and irregularly pentangular, moderately inrolled, outer extremity slightly rounded and obliquely truncated from front outward and downward, the basal portion showing a broad channel beneath the projecting coronal border; anterior border slightly sigmoidally curved, forming nearly a right angle with the outer margin, coronal enamel forming a narrow crenulated fold above the nearly vertical-channeled base; posterior border similarly curved, but of greater extent, agreeing in other respects with the opposite side; inner margin broadly rounded or obtusely angular, coronal portion well-defined from the deep, somewhat produced and shallow-channeled base (in most specimens the basal portion is worn away, the crown projecting beyond its original support). Coronal surface moderately arched in both directions, traversed a little posterior of the middle by the median ridge, which forms a rather prominent angulation partaking of the curvature of the defining borders, anterior slope broader than the somewhat more concave and abrupt posterior declivity, which latter is produced into an obtuse alation at the extreme posterior angle, beyond which extends the base terminating in an obtuse spur. Surface minutely and closely punctate. The proportionate dimensions of large examples vary considerably, according to the state of truncation of the inrolled extremity; in other respects, however, as in general outline and coronal contour, the observable variation of individual teeth is comparatively unimportant, save what is attributable to wear while in use. Both the anterior and posterior borders are faintly undulated, suggesting their association with series of smaller teeth. The latter condition is even more markedly exhibited in the teeth (including this particular form,) from the Chester limestone, *Psephodus crenulatus*, N. and W., with which the teeth described under the name *Aspidodus convolutus*, N. and W., is specifically identical. The posterior sinuations are fewer, indicating larger teeth for the contiguous series than those at the opposite border. The relations of crown to base are shown in the illustrations given of the teeth in question. These teeth probably occupied a median position upon the rami of the mandible. An ordinary-sized tooth measures in greatest breadth between the inner angles 40 m m; ditto, across outer extremity 25 m m; length along antero-lateral border 20 m m; ditto, postero-lateral border 30 m m; depth of tooth at middle of anterior border 3 m m; ditto, middle of inner margin 5 m m; greatest length along coronal ridge 40 m m. The proportions will, of course, be found to vary in individuals of the same age, in accordance with the abbreviation of the outer extremity.

Teeth strikingly in contrast with the preceding form, occurring in the collection with the same frequency, but possessing superficial characters which strongly suggest their intimate connection with that form; may be regarded as the opposed form of the upper jaw. They are distinguishable by their trapezoidal outline and relatively uniform low coronal surface, and proportionally less robust build. Outer extremity obliquely truncated in the same direction observed in the previously mentioned form, or from the anterior angle outward and downward, and forming nearly a right angle with the antero-lateral border, the narrow coronal fold projecting beyond the furrowed base, and somewhat irregular in outline, forming an articular edge with a similar preceding tooth of the same series; antero-lateral border proportionately shorter than in the first noticed form, slightly curved sigmoidally, nearly vertical, with a narrow channel defining the crenulated coronal fold from the base, and more or less distinctly undulated; postero-lateral border somewhat more strongly curved, obtusely rounded at the inner posterior angle, the crenulated coronal fold slightly overarching the basal portion, which is also channeled and undulated as in the opposite border; inner margin broadly rounded, base excavated as in the previously described form. Crown very slightly arched transversely, well-preserved specimens showing two obscure longitudinal prominences, one near and rising rather abruptly from the posterior border, the other a little anterior of the middle; a third, and perhaps sometimes quite as well marked ridge, occurs just back of the anterior border. Coronal surface finely and closely punctate. A medium-sized tooth measures across the inner margin 29 m m; ditto, outer margin 16 m m; length along anterior border 21 m m; ditto, posterior border 32 m m; depth of tooth at middle of anterior border 3 m m; ditto, inner margin about 5 m m.

A very small specimen which is provisionally identified with the maxillary form of the present species, shows a proportionately shorter tooth of a more rhombic outline, the outer margin, also anterior and posterior borders, distinctly crenulated, the former strongly so, and further distinguished by the gradual convergence of the lateral borders, greater and more regular transverse convexity of the coronal region, as contrasted with the typical specimens. These features of coronal contour are also intimately shared by a more elongate mature tooth, but which, though imperfect along the anterior border, and considerably worn towards the outer extremity, evidently closely agrees in outline with the typical examples.

Compared with other American Carboniferous forms of *Psephodus*, the present offers characteristics readily distinguishing them specifically. From *P. crenulatus* (N. and W.) of the Chester formation, the species differ in the uniformly larger size of the teeth, representing the dentition of different parts or opposite jaws. The large median teeth, probably belonging to the lower jaw, differ in being less massive, possessing fewer and less distinct undulations in either border supposed to have relation to contiguous series of smaller teeth, and the less strongly marked crenulations of the narrow coronal fold. The depressed trapezoidal teeth included in the second form described under the above specific caption, and which are supposed to have belonged to the upper jaw, differ from the corresponding teeth of the Chester species in essentially the same respects above cited, with perhaps less marked obliquity of inner and outer margins and less strong spiral inrollment. Examples of both of the above forms of the Chester species show the entire margins and borders of the teeth to have been crenulated; besides they are more or less deeply notched in one or other border, showing the manner of coalescing of transversely elongate teeth of the younger with the broad long plates of the later stages of growth. The latter feature assumes various phases, from a shallow undulation in the border to a deep slit extending through the thickness of the crown and base, the impinging margins being crenulated as in the inner and outer margin of entire individuals. None of the Kinderhook examples, however, show this latter feature, yet it may be expected to occur in them as well as in the Chester species. A medium-sized tooth of the Chester species affords the following measurements: Breadth across inner margin, 22 mm.; ditto, outer margins, 13 mm.; length along anterior border, 13 mm.; ditto, posterior border, 16 mm.; thickness of tooth at middle of anterior border, 3 mm.; ditto, posterior border, 4 mm.

The teeth of the present species differ from European species *Psephodus magnus*, Agass., as also from the Chester *P. crenulatus* (N. and W.) in their more symmetrical outline and distinct definition of the angles. The Chester species, perhaps, bears more intimate comparison, but it is not known to have attained nearly the size of the European species. The Kinderhook teeth under consideration are further distinguished by the comparatively distinct angulation of the coronal ridge of the mandibular form.

PSEPHODUS PLACENTA, (N. and W., sp.)

Pl. II, Fig. 5-8.

Helodus placenta, NEWBERRY and WORTHEN, 1866, Ill. Geol. Surv., II, p. 80, Pl. V, Fig. 4, 4a.

Associated with the forms last described under the name *Psephodus obliquus*, the collections contain a few examples of teeth, which so far as relates to superficial markings and general appearances, might be presumed to have belonged to the fishes that bore those teeth. But in all the collections from Chester localities, where the forms of *P. crenulatus* abound, there is not a single representative of the form here alluded to. Therefore, in recognition of its distinctive features, it is provisionally referred to a distinct species.

As at present understood, only two forms of teeth have been recognized as probably belonging to this species. First, median form of the upper jaw (?); Teeth irregularly quadrilateral in outline, moderately inrolled spirally, anterior and posterior borders differing little in relative length, converging at a slight angle, the narrow enamel fold defined by a slight groove from the basal portion, which shows coarse verrucose markings; inner margin broadly rounded with a slight sigmoidal curvature extending into the obscure posterior alation, the vertical plane of the base equal in depth to the height of the enamel fold from which it is well defined; outer margin obliquely truncated from the anterior angle downward and outward, usually much worn and otherwise mutilated. The anterior and posterior borders show more or less distinct and rather wide undulations. Coronal surface uniformly and closely punctate, somewhat strongly arched transversely into a broad rounded prominence culminating a little anterior to the median line, posterior slope gently concave. Breadth of medium-sized tooth across inner margin, 23 mm.; ditto, outer margin, 18 mm.; length along antero-lateral border, 20 mm.; about equal to the opposite border; depth of tooth at middle of anterior border, 2-5 mm. Second, median form of the lower (?) jaw: Teeth corresponding with the second form, described under *P. obliquus*, and having the same general outline, but distinguishable by the less rapid convergence of the lateral borders and the considerable gibbosity of the coronal region, which rises into a low broad prominence, traversing the crown nearly centrally, or a little abaft the median line. The large uniqu individual of this particular form afforded by the collections, is somewhat mutilated, the borders and extremity not being clearly shown; the inner margin is broadly rounded, with a slight sigmoidal oblique course, the crown surface punctate as in the other forms.

Comparisons of the first above mentioned form with the type specimen described by Messrs. Newberry and Worthen, under the name *Helodus placenta*, leaves no doubt as to their specific identity. The original specimen figured in the report of the Illinois Geol. Survey, II, Pl. V, fig. 4, 4a, is that of a small individual, the transverse diameter of which considerably exceeds the length from within outwards, the inner margin and base being in an extraordinarily perfect state of preservation, even showing the delicate crenulations of the rather heavy coronal fold that rises from and projects somewhat beyond the mural basal area. The outer portion of the tooth, on the other hand, is much worn, though the entire outline is still preserved, its characteristics being well reproduced in one of the figures illustrating the species as herein interpreted.

Compared with *Psephodus obliquus*, the forms of the present species reveal the following salient distinctions: The supposed mandibular median teeth are relatively narrower, lateral borders less rapidly converging, the more nearly central position of the axis of the coronal ridge, and the less angularly rounded inner margin; in the supposed opposed form of the upper jaw, the lateral borders more gradually converge the anterior position and greater prominence of the coronal ridge, while the inner margin is less obliquely rounded than obtains in the corresponding forms of the last described species.

Geological position and locality: Upper fish-bed of the Kinderhook formation; Burlington, Iowa.

PSEPHODUS? SYMMETRICUS, ST. J. and W.

Pl. I. Fig. 6, 7.

The present species is represented by a single form, with which only one or two individuals, of doubtful generic relations, have thus far been provisionally identified. The form corresponds to that referred to the median position on the lower jaw. The typical example is that of a tooth below medium size, sub-trapezoidal in outline, moderately arched from within outwards and somewhat closely inrolled, giving to the outline a relatively great breadth as compared to the length of the tooth. The outer margin and coronal region is worn and broken away, nor are the postero—and antero—lateral borders sufficiently preserved to show more than the projection of the basal rim beyond the coronal limits, as obtains in both examples, the borders gradually converging, coronal limits defined from the basal rim by a shallow sulcus; the inner margin is broadly rounded, with a slight sigmoidal curvature in passing from the obtuse anterior angle to the slightly produced posterior angle. The crown surface gently rises from the antero-lateral border, culminating in a broad low crest situate in the posterior half of the coronal area, thence more steeply sloping into the narrow shallow concavity parallel with the posterior border; surface minutely punctate. Greatest diameter across the inner margin .17 mm.; length along the antero-lateral border 7.5 mm.

The type specimen shows a faint longitudinal depression near the median line, which does not appear to have been produced by wear as it descends to the unworn enameled inner margin, and toward the antero-lateral border the surface is marked by a thread-like groove, defining a narrow plain belt along that side, which is apparently also a permanent constituent of the coronal contour.

Another and smaller tooth belonging to the left ramus of the lower jaw, shows nearly the same outline as the specimen described above, but it is distinguished by the greater prominence of the coronal ridge and the somewhat greater obliquity of the postero-lateral border. As in the above example, the antero-lateral border has a moderately oblique course from the obtuse inner angle outward and forward, and is similarly marked by the produced basal rim; the posterior depression, however, is quite obsolete, the slope from the summit of the coronal ridge to the rounded fold along the postero-lateral border showing scarcely the least transverse concavity; on the other hand, while the gentler declivity in front is faintly depressed, it is destitute of the impressed thread-like line and narrow belt parallel with the anterior border observed in the larger tooth. The surface punctation of the smaller specimens is appreciably coarser and more like that of the associated teeth of *Psephodus*, and in both the remnant of coronal enamel along the inner margin is traversed by similar faint parallel lines of growth.

In the process of the preliminary distribution of the materials of the collections for study, the teeth upon which the foregoing notices are based were referred to *Psephodus obliquus*, a relationship which may yet prove to be well founded—the smaller of the examples above referred to possibly representing the young stage of the large teeth described under the latter designation. The latter specimen, however, shows the inrolled extremity entire, instead of the oblique truncation such as distinguishes all mature individuals of *Psephodus*, while the strong inrollment and consequent strongly arched longitudinal profile offer marked contrast with the forms of *Psephodus* with which the present teeth were associated. The larger example bears a striking resemblance to the mandibular posterior form of *Cochliodus*; but of the latter genus no other remains have thus far been discovered in Kinderhook horizons affording the teeth above noticed.

Geological position and locality: Kinderhook formation; Burlington, Iowa.

PSEPHODUS LATUS, ST. J. and W.

Pl. II, Fig. 1, 3.

Teeth small. Mandibular median (?) form sub-triangular in outline, moderately arched in the direction of inrollment. Antero-lateral border nearly straight, undulated, the crenulated coronal fold sharply inbeveled to the channeled basal portion; postero-lateral or oblique border rapidly converging towards the outer extremity, making an angle of 55° with the opposite border, with which it agrees in other respects, although the basal portion is thicker and expanded posteriorly beyond the limits of the coronal fold; inner margin at right angles to the antero-lateral border, broadly arched from the obtuse anterior angle round the base of the coronal prominence, behind which it makes a slight concavity on the way to the subacute posterior extremity. Coronal surface gradually rising into the rounded crest which lies a little behind the median line, the posterior slope slightly concave, the anterior slope even less so, alate expansion obscurely defined. Surface marked by minute, widespaced punctæ. Greatest lateral diameter across the inner margin 13 mm.; length along antero-lateral border 9. mm.

The above described form is represented by a couple of nearly entire teeth, in the collection of Mr. Van Horne. They are closely related to the corresponding form of the representative species occurring in the Chester formation, which latter, however, is distinguished by the finer punctation, more oblique backward course of the inner margin, and less central position of the coronal ridge.

The St. Louis collections also afford many examples of the diverse forms of teeth which have usually been identified with the genus *Helodus*, but which, possessing certain characteristics in common with unquestionable forms of *Psephodus*, seem to possess intimate generic relations with the present form. The latter teeth may be distinguished in a general way by their eccentric coronal prominence, crenulated lateral borders and margin of the abrupt outer coronal slope, presenting extreme variation in outline and coronal contour. Not infrequent examples are met with showing the downward and outward produced base characteristic of *Lophodus*, as obtains in *L.* (*Helodus*) *didymus*, Ag.; but more frequently the posterior basal portion is inbeveled, indicating that the individual may have constituted one of a series of teeth more or less perfectly joined at their bases, forming a continuous plate the same as is known to occur in individuals of *Psephodus*. Varying from the asymetrical contorted forms to broad surfaced sublunate symmetrical teeth, almost every conceivable variation attributed to this class of teeth is observed amongst the St. Louis material, the same as occurs in the Kinderhook and Chester collections. The specific identity of these diverse forms with the teeth above described is in many instances as clearly indicated as may be under the circumstances; but that all of them belong to a single species, we would not undertake to affirm with equal confidence.

Geological position and location: St. Louis limestone; Alton, Ill., St. Louis, Mo.

PSEPHODUS CUNULATUS, St. J. and W.

Pl. II, Fig. 4.

Tooth small, quadrato-lunate in outline, lateral borders nearly parallel, posterior margin strongly arched forward, making obtuse angles with the lateral borders, anterior margin correspondingly concave, terminating in the acute, outward-produced lateral angles. Coronal region moderately arched in both directions, with an abrupt declivity bordering the anterior side, the surface presenting a somewhat uneven contour, which is also discoverable in the slightly greater prolongation and rounding of one of the outer lateral angles, and the relatively greater depth of the tooth at that side; the enamel makes a distinct narrow belt sharply inbeveled to the basal portion all round, lateral borders obscurely undulated, posterior edge plicato-denticulate, outer margin occupied by vertical plicæ terminating below in deep crenulations. The base is relatively thick; inferior surface slightly depressed and smooth, lateral borders nearly vertical and faintly channeled, inner margin deeply channeled, together with the coronal belt, and terminating below in a thin rim slightly in advance of the coronal edge, the edges all round coarsely pitted. Coronal surface presents a somewhat irregular, minute punctate structure, showing marked evidences of attrition from use. Breadth across outer margin 9.5 m m.; length along one of the lateral borders 5 m m.; length along median line 8 m m.

The unique specimen above described represents a nearly perfect tooth of a form not before met with. Its affinities are unquestionably with *Psephodus*, with whose numerous dental remains it is associated. The narrow forms of *P. crenulatus* (N. and W., sp.,) present, in their crenulated margins, striking resemblance with the present tooth, even as to the details enumerated above, though perhaps not so pronounced as observed in the individual described. The same observation holds as regards the coronal contour, which is gradually sloped from the brink of the abrupt outer declivity to the inner margin. It is, therefore, with some doubt its specific distinctness is recognized; it may prove to belong to a posterior row of teeth of one or other jaw, or possibly interposed near the symphysis between the flat, narrow, *Helodus*-like teeth, whose specific identity with the contorted, inrolled median plates of *P. crenulatus* can scarcely be questioned. Its salient contrasts, compared with the forms associated under the latter specific designation, consist in the more symmetrical outline, and coarser, irregular character of the coronal punctæ.

Geological position and locality: Chester limestone; Chester, Illinois.

GENUS TÆNIODUS, L. de Koninck Mss.

Teeth representing the posterior form of the upper jaw attain large size, sub-rhomboidal or oblique-trapezoidal in outline, moderately arched from within outward, and inrolled, more or less obliquely, outward and forward. Lateral borders regularly and gradually converging toward the outer extremity, which may be truncate, as in *Psephodus*, of moderate depth, inferior or basal portion channeled and distinctly defined from the coronal fold, which forms a sort of coping along the upper edge; antero-lateral border relatively short, having a more or less oblique outward and forward course and slightly concave curvature between the obtuse inner angle and point of inrollment; postero-lateral border gently and regularly arched from the subacute posterior angle, and gradually converging outward with slightly greater obliquity than the opposite border; inner margin making a gentle curvature from the posterior angle forward to the rounded angle at the base of the coronal prominence, where it is suddenly deflected forward with a slight concavity to the anterior angle, making a very obtuse angle with the posterior half of its course. Coronal contour presenting a simple posterior prominence culminating in a low, rounded crest, the broad posterior slope usually slightly convex, though sometimes faintly depressed, that on the opposite side apparently more abrupt and merging into the slightly depressed anterior area; the surface is more or less distinctly undulated by transverse ridges separated by narrow furrows, conforming in outline to the inner margin. The usual punctate structure occurs over the entire coronal region, the pores showing a tendency to irregular elongation in the axis of the transverse sulci. Inferior surface of teeth showing the dense inferior layer longitudinally striated; thickest beneath the coronal ridge.

The foregoing diagnosis applies to a group of teeth meagerly represented in the collections by the form homologous with the posterior teeth of the upper jaws of *Cochliodus* and allied genera. A single, nearly perfect specimen from the Carboniferous limestone of Vesi, Belgium, in the De Koninck collection, belonging to the Museum of Comparative Zoölogy, at Cambridge, bears the manuscript name, *Tæniodus contortus*, de Kon? The characteristics which distinguish this specimen are intimately reproduced in the American samples hereinafter particularly noticed, and which constitute a well-defined form, for which we have adopted the unpublished appellation bestowed upon the typical species recognized by Dr. de Koninck. The relations of these teeth are apparently near *Psephodus*, from the supposed maxillary median forms of which they are indeed chiefly distinguishable by the pronounced differentiation of the coronal contour, in which respect they approach nearer certain remote forms of typical Cochliodonts, e. g., *Stenopterodus*.

The American species are readily distinguishable from the congeneric Belgian species, *T. contortus*, de Kon. The latter is remarkable for its comparatively strong inrollment, slightly depressed posterior coronal slope; in general proportions and outlines it bears closest resemblance to the Chester teeth, *T. obliquus*.

The genus is known only from Carboniferous strata, of which, besides the typical European representative, there are authentic determinations of three species from America, all from the Lower Carboniferous series.

TÆNIODUS FACIATUS? (N. and W. sp.)

Pl. XIII, Fig. 9.

Deltodus faciatus, Newberry and Worthen, 1870, Ill. Geol. Surv., IV, p. 366, Pl. III, f. 17.

Maxillary posterior tooth attaining large size, elongate subrhomboidal in outline, gently arched in the direction of inrollment. Antero-lateral border relatively short, obliquely produced outward and forward at an angle of about 25° with a line connecting the inner angles of the tooth; postero-lateral border very gradually converging toward point of inrollment with a gently arched course —character of coronal fold and basal rim not known in either border; inner margin making nearly a right angle with the postero-lateral border to a point about midway, where it is abruptly rounded and deflected forward with a slightly concave course thence to the obtuse anterior angle, worn specimens beveled inferiorly. Crown surface chiefly occupied by the posterior prominence, which presents a broad gently convex slope rising from the postero-lateral boarder into the crest, the opposite side more abruptly descending and merging into the shallow depression occupying the anterior portion of the crown; the surface is more or less strongly marked by transverse undulations conforming to the inner margin, the narrow intervening grooves showing coarse and irregularly elongate punctæ which elsewhere present at the triturating surface merely circular orifices spaced by twice or thrice their own diameter. The original specimen measures in transverse diameter between the inner angles about 38 m m.; greatest length above 50 m m.

The above species was originally described from a unique imperfect example, and the very few subsequent accessions are even more fragmentary, and none are sufficiently entire to give the exact proportions of the perfect tooth. The fragments are, however, readily recognizable by their peculiar coronal contour and transverse undulations. In the light of these imperfect data, there appears to be specific identity between the Keokuk teeth and a couple of fragments of the same forms discovered by Mr. Van Horne in the Warsaw beds; the Keokuk specimens are more worn and present a less strongly undulated surface than obtains in the Warsaw examples, which otherwise, in outline, proportions and general coronal contour, agree well with the Keokuk teeth. A fragment of another specimen, from the St. Louis formation, near Pella, Iowa, representing a tooth of the ordinary size attained by the present species, is also undistinguishable from the individuals just mentioned. The present form presents marked contrasts with that noticed from the Chester formation under the head of *Tæniodus obliquus*, as remarked in the observations appended to the diagnosis of the latter species.

Geological positions and localities: Keokuk limestone, Warsaw and Hamilton, Illinois. Also, sp.?, Warsaw limestone, above Alton, Ill.; and sp.?, St. Louis formation, Pella, Iowa.

TÆNIODUS REGULARIS, St. J. and. W.

Pl. XIII. Fig. 11.

Teeth of large size. Maxillary posterior (?) form subhrhomoidal in outline, moderately arched in the direction of inrollment. Antero-lateral border very oblique in its forward and outward course, the coronal belt nearly vertical and comprising half the height of the border, a slight sulcus defining it from the basal portion, the inferior edge of which is broken away; postero-lateral border almost parallel with the opposite side, making an angle of about 55° with a line drawn between the angles of the inner margin, coronal enamel apparently forming a narrow fold, basal border not preserved; inner margin broadly arched from the subacute posterior angle round the base of the coronal prominence, thence with a slight concavity on the way to the obtuse anterior angle, worn specimens inbeveled below. Two-thirds or more of the coronal surface is occupied by the posterior lobe or prominence, which is gently and regularly arched transversely, the anterior slope descending into the very shallow concavity of the anterior portion of the crown, which is abruptly truncated at the articular border; surface marked by irregularly spaced transverse undulations, which are nearly obsolete in worn specimens, and producing a banded appearance conforming in outline to the inner margin; the punctæ are small, moderately closely arranged and uniform, save in the axes of the transverse furrows where they often present irregular elongate orifices. The surface of the dense inferior layer is smooth or irregularly striated longitudinally. The tooth is very thick and massive beneath the coronal prominence, whence its substance gradually diminishes in thickness towards the lateral borders. Greatest breadth of tooth across the inner margin 45 m m, length of antero-lateral border to point of enrollment probably nearly 22 m m, or in the neighborhood of two-thirds that of the postero-lateral border.

The description is founded upon a unique example purporting to have been derived from a locality on the Warsaw limestone near Bedford, Indiana. The tooth is unmistakably congeneric with the form noticed under the name *Tæniodus fasciatus*, but representing a somewhat larger and more entire individual. It is, however, specifically distinguishable from the latter by the proportionately greater breath and transversely more regularly arched coronal prominence, which does not exhibit the sudden deflection in the course of the transverse undulations noticeable in the above cited species.

Geological position and locality: Warsaw limestone, near Bedford, Lawrence County, Indiana.

TÆNIODUS OBLIQUUS, St. J. and W.

Pl. XIII, Fig. 10.

Maxillary posterior (?) teeth of medium size, obliquely trapezoidal in outline, somewhat strongly arched from within outwards. Antero-lateral border obliquely produced outward and forward at an angle of about 20° with a right line connecting the inner angles of the tooth, coronal enamel forming a narrow belt rounded to the basal border, which was probably of shallow depth; postero-lateral border converging toward point of inrollment at an angle of about 35° with the opposite border, and similarly defined by the rounded enamel fold, which in both borders shows indistinct traces of minute crenulation, basal rim in either border not known; inner margin making a broad sigmoidal curvature, broadly arched round the base of the coronal prominence from the subacute posterior angle, with a moderate concavity in passing to the obtuse anterior angle, in worn specimens inbeveled inferiorly. Coronal prominence occupying three-fourths of the entire area of the crown surface, moderately elevated and broadly arched transverely, the broader slope regularly rising from the postero-lateral border into the nearly median low crest and slightly more steeply sloped into the shallow depressed belt occupying the anterior portion of the surface; the coronal surface is traversed by strong, more or less regularly spaced undulations parallel with the inner margin, the intervening sulci occupied by the irregularly elongated orifices of the medullary tubes which elsewhere appear as minute circular pits, spaced by three times their own diameter, surrounded by low rims with faint stellate radiations; in worn surfaces the transverse undulations become obsolete, though the position of the sulci is still plainly discernible by the parallel bands of coarse pores. Greatest lateral diameter of a medium size tooth 20 m. m., length along antero-lateral border to point of inrollment about 15 m. m.

The above described form which was discovered by Dr. Hambach, is represented by three individuals, all belonging to the right ramus of the upper jaw, one only presenting a nearly entire tooth. This is sufficiently perfect to permit satisfactory comparison with congeneric forms and the discrimination of its specific peculiarities. Intimately allied to the earlier occurring species, it is at the same time distinguishable from that described from the Warsaw horizon of Indiana, *Tœniodus regularis*, by its relatively narrower proportions and more oblique outline; "it differs from *T. fasciatus*, of the Keokuk formation, as also the form provisionally identified with that species from the Warsaw beds above Alton, both in its greater obliquity and transverse diameter. At the same time it bears a general resemblance to the Belgian species *T. contortus*, De Kon., which latter, however, is relatively longer, the enamel fold of the lateral borders much more strongly developed, and in the distinct depression of the posterior slope of the crown surface.

Geological position and locality: Chester limestone, Chester, Illinois.

GENUS VATICINODUS[1], St. J. and W.

The distribution and investigation of the materials illustrating *Deltoptychius* and allied genera, have brought into prominence homologous forms of teeth which range themselves under a group apparently characterized by persistent features, in contradistinction to *Deltoptychius* on the one hand, and *Stenopterodus* on the other, and which, if we are correct in inferring their generic distinctness, offer a premonition of the later differentiated *Orthopleurodus*, etc. Unfortunately, however, the state of preservation of the material illustrating these forms is in no instance such as leads to indubitable conclusion in regard to their generic distinctness from *Stenopterodus*. Hence the various specific categories into which the forms from the several formations readily resolve themselves, are provisionally recognized under the above generic designations.

The forms above referred to represent the posterior teeth of the upper and lower jaws. The maxilliary form is in every respect like the corresponding teeth of *Deltoptychius*, save in the apparent absence of the least vestige of the presence of the secondary lobe, the entire anterior portion of the tooth forward of the posterior prominence presenting a plain surface, such as obtains in *Stenopterodus*. The anterior-lateral border is probably truncated from the inner angle slightly obliquely outward and forward, in which respect it differs from the prevalent condition observed in typical *Deltoptychius* and *Stenopterodus*. The mandibular form is also in general outline and contour like that of the former genus; but the individuals here referred to do not preserve a trace of the narrow plain belt such as in *Deltoptychius*, distinctly defines the median lobe from the edge of the abrupt antero-lateral border. In the latter particular the teeth referred to bear striking resemblance to the mandibular posterior form of *Orthopleurodus*. As all of the few examples of this form are represented by evidently worn individuals, it cannot be denied that they may be merely abraded teeth of *Deltoptychius*.

With one or two exceptions, the species noticed in this connection are unquestionably distinct from those hereinafter described under the head of *Deltoptychius*. These possible exceptions relate to the species noticed respectively from the St. Louis and Chester formations, as will be remarked further on. The earliest representative occurs in the upper horizon of the Kinderhook formation, the Upper Burlington, St. Louis and Chester each contributing representative forms, while a single form from the Upper Coal Measures, and one from the Lower Coal Measures, are with doubt here referred. The Kinderhook and Upper Burlington afford the typical representatives, being represented by examples which it is difficult to believe ever possessed the distinctive characters essentially attributed to *Deltoptychius.* We owe to the kindness of Lord Enniskillen opportunity to compare, from drawings, a magnificent tooth derived from the Carboniferous limestone of Oreton, in Shropshire, England, and belonging to the museum at Florence Court, Ireland. The latter tooth shows a large example, above four inches in its greatest diameter, and of proportionate dimensions, of the maxillary posterior form. So far as it is possible to judge from the drawings, it possesses precisely the coronal contour characteristic of the teeth of the corresponding form noticed in the following pages. The resemblances in common between the Shropshire and the Kinderhook teeth are especially pronounced, neither the one nor the other would be mistaken for a typical *Deltoptychius.* In both examples the posterior prominence is obscurely defined from the plain anterior region, which shows not a trace of secondary lobe. The genus may also include the tooth described by Dr. L. de Koninck[1] under the name *Streblodus tenerrimus,* from the Lower Carboniferous deposits of Tournay, Belgium.

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[1] *Vaticinus*, prophetical; *odous*, tooth. In allusion to its being the supposed earliest of the Cochliodonts.

Again, if the evidence be fairly admissible, the forms here especially referred to, offer some most interesting suggestions bearing on the derivation of allied and coëxisting generic forms. That referred to under the name *Vaticinodus vetustus,* from the Kinderhook, represents the earliest species not only of this particular group, but also of typical *Cochliodonts.* Passing up into the Upper Burlington, next is met with an apparently congeneric form *V. discrepans.* During the latter epoch *Chitonodus,* the immediate precursor of *Cochliodus,* was introduced, and also *Deltoptychius* and *Stenopterodus.* The latter is plainly a somewhat more pronounced differentiation, while *Deltoptychius* holds an intermediate place between the primal groups and *Stenopterodus.*

(NOTE.) [1] Faune calcaire Carbonifère de la Belgique, II, p. 55, P. VI, f. 13.

VATICINODUS VETUSTUS, St. J. and W.

Pl. III, Fig. 1.

The unique example of the present species represents a large posterior tooth belonging to the left ramus of the upper jaw. It is elliptical or spatulate in general outline, moderately arched longitudinally, and apparently strongly inrolled along the outer margin, terminating posteriorly in a sharply-rounded angle formed by the posterior basal spur, which extends conspicuously beyond the coronal limits, angle of obliquity of the antero-lateral border not shown, but evidently forward from the inner angle. The tooth is considerably thickened in the region of the posterior border, its substance rapidly diminishing in the opposite direction, on account of which the anterior articular border is liable to mutilation, as is the case in the present example. The basal rim along the postero-lateral border forms a prominent platform projecting beyond the coronal border for half the distance toward the point of inrollment, the coronal enamel forming a heavy rounded unbeveled belt distinctly defined from the basal portion, which latter also forms a deep border along the inner margin of the tooth. Inferior surface marked by interrupted coarse verrucose striæ, conforming in direction to that of the inrollment of the tooth. The crown still retains along the inner margin the original coating of glossy enamel, the summit and outer region exhibiting progressive degrees of wear from use, and fine punctate structure, inner margin distinctly defined from the base by the limits of the enamel coating and marked by parallel lines of growth; posterior prominence occupying perhaps one-third the lateral diameter of the crown, presenting a broad low convexity flattened along the crest and somewhat depressed from within outwards, where it merges into the broader anterior area, which latter is smooth and without longitudinal folds. From the surface conformation and direction of inrollment it is safe to infer the somewhat oblique outward and forward course of the antero-lateral border. Greatest length of crown probably near 13 centimetres, to extremity of posterior spur 15 centimetres; greatest breadth near middle of tooth along a line diagonal to the longitudinal axis [illegible] m m.

The mutilated condition of the sole example representing the species does not allow the making out of the character of the antero-lateral border; otherwise the specimen permits of satisfactory comparison with allied congeneric teeth. Of the latter there appears to be a strong resemblance to the large tooth found at Oreton, in Shropshire, drawings of which were kindly communicated by Lord Enniskillen, showing a tooth of nearly equal dimensions and differing chiefly from the present form in the less prominent and well defined posterior coronal lobe, and perhaps less massive proportions in the region of the coronal prominence. The latter form we are not aware has been described. The distinctions of the present form, compared with the smaller forms hereinafter described, need not receive further notice in this place. The Belgian Carboniferous tooth described by Dr. L. de Koninck under the name *Streblodus tenerrimus*, is under medium size, and is further distinguished from the present tooth by its relatively narrower posterior prominence and stronger spiral inrollment.

Geological position and locality: This unique example was derived from the uppermost bed of the Kinderhook series exposed in the banks of Long Creek, a tributary of Skunk river, Des Moines Co., Iowa.

VATICINODUS DISCREPANS, St. J. and W.

Pl. III, Fig. 2, 3.

The collections contain three or four examples of maxillary posterior teeth, which, although in a fragmentary state of preservation, apparently differ from any of the associated species thus far made known from the Upper Burlington horizon, in which the present form was discovered by Mr. Springer. They are evidently referable to the above genus, and offer the following distinctive features, especially compared with the much more prevalent forms of *Stenopterodus planus*, with which they are associated, and for which they are most liable to be mistaken: Attaining a larger size, the teeth are specially distinguished by the much more rapid convergence of the postero-lateral border, and the consequent greater obliquity of the coronal prominence, which presents a broad, very slightly convex posterior slope, and abrupt declivity in front, where it is defined by a slight angulation from the plain anterior area. The inner margin is more sharply rounded in the region of the base of the coronal prominence, slightly concave or constricted in front, and thence to the obtuse anterior angle it pursues a gently arched or nearly direct course. The coronal surface shows minute, closely set punctæ; toward the inner margin the enamel layer is undulated by transverse lines of growth. The absence of distinct longitudinal arrangement of the punctæ also contrasts with the above named species. A mature individual attains a breadth across the inner margin of 27 m m., and a length along the antero-lateral border of probably 10.5 m m.

We have thus far failed to recognize other and probably associate forms of the above species, so that it is impossible to say how intimate its relations are with the teeth that constitute the representative forms of the allied genus *Stenopterodus*. The general outline and the obliquity of the coronal prominence offer striking resemblances to *Deltoptychius*, but the absence of the secondary lobe anterior of the principal prominence precludes its reference to that genus.

Geological position and locality: Upper Burlington limestone fishbeds; Buffington creek, and Augusta, Iowa.

VATICINODUS? SIMPLEX, St. J. and W.

Pl. IV, Fig. 22-26.

Teeth of small size. Maxillary posterior teeth subelliptical in outline. Antero-lateral border somewhat obliquely truncated from the obtuse inner angle forward to point of inrollment; postero-lateral border very rapidly converging from the sharply rounded posterior extremity toward point of inrollment, forming, an angle of 20° to 30° with the opposite border, making a broad gentle arch; basal border channeled and posteriorly produced into a thin rim which extends beyond the limits of the inbeveled coronal border; inner margin in front nearly parallel with the postero-lateral border, strongly and abruptly arched round the base of the coronal ridge to the posterior extremity, basal portion relatively deep and placed in the same plane as the crown from which it is defined by the inbeveled inferior belt of enamel. Coronal region moderately arched in the direction of inrollment, posterior lobe occupying rather less than half the lateral diameter of the crown, very oblique, and sufficiently well-defined in front, moderately arched transversely with a slight depressed belt along the postero-lateral border; anterior portion or neck nearly plain, or very faintly convex transversely, with an obscure revolving sulcus margined by a narrow plain belt along the antero-lateral border,—in worn examples, even the posterior lobe is imperfectly defined in front from the plain anterior neck. Surface along inner margin often preserving the external coating of dense opaque enamel, with more or less distinct lines of growth; otherwise the surface exhibits a minute pitted structure produced by the relatively widely-spaced punctæ. A mature tooth measures in greatest width between the inner angles 10 m m.; length of antero-lateral border to point of inrollment 4.5 m m.

Thus far only the posterior teeth of the upper jaw have been identified. The fragmentary condition of the majority of the specimens often renders their identification with one another a difficult matter, not to mention the necessary comparisons in order to determine their relationship with other similar forms occurring in the same strata. In their general aspect these teeth bear a striking resemblance to *Deltoptychius expansus;* but they may be distinguished by the absence of the median sulcus and subordinate ridge in front of the posterior coronal prominence, and specifically by their narrow transverse diameters.

Associated with the above mentioned teeth, certain forms representing the mandibular posterior teeth occur, which might be mistaken for more specimens of the homologous form of *Deltoptychius expansus.* None of the latter specimens are in a state of preservation to show their distinctive features with sufficient clearness to dispel all uncertainty in regard to their generic relations. Their coronal region is divested of the superficial enamel coating, exposing the minute close punctate structure such as appears in worn surfaces, and presenting a nearly plain coronal prominence without subordinate narrow belt along the antero-lateral border, as occurs in typical examples of *Deltoptychius;* in the latter respect these teeth approach the corresponding form referred to *Orthopleurodus,* and while we are in doubt as to their actual affinities, they are provisionally placed in the present specific association, of which characteristic examples of both forms are presented in the illustrations. Compared with the homologous teeth of *Deltoptychius expansus,* they are further distinguished by the less oblique backward course of the inner margin, which forms nearly a right angle with the antero-lateral border, the appreciably narrower and less upraised alation, which is marked near the border by a slight furrow or angulation from which rises the narrow marginal belt along that side, and which is inbeveled to the channeled basal portion. The deep antero-lateral border is abruptly truncated, half its height enveloped in the belt of coronal enamel, which is well defined from the downward and slightly outward produced basal rim. A medium sized tooth measures between the angles of the inner margin 5 m m, and about the same as the length along the antero-lateral border.

Geological position and localities: St. Louis formation: St Louis, Mo., Alton, Ill., Pella, Iowa.

VATICINODUS? SIMILIS, St. J. and W.

Pl. IV. Fig. 17-19.

Maxillary posterior teeth very small, subspatulate in outline, very obliquely inrolled. Antero-lateral border with moderate obliquity outward and forward, coronal fold very narrow and inbeveled to the shallow, channeled basal rim; postero-lateral border slightly arched, basal portion channeled and limited above by the inbeveled coronal fold, posteriorly expanding beyond the coronal border terminating in the sharply-rounded posterior extremity; inner margin abruptly and deeply arched from the posterior angle round the base of the coronal prominence, thence more gently curved to the obtuse anterior angle. Coronal prominence occupying about half the entire area of the crown, moderately and regularly arched transversely, culminating in the low rounded crest near the anterior side where it is more or less well defined from the plain anterior area into which the slope merges. Surface closely and finely punctate, the anterior region showing faint revolving plicæ. Breadth between the angles of the inner margin about 9 m m.; length along antero-lateral border probably 3 m m. A large tooth measures 22 m m. across the inner margin, and 6 m m. at the antero-lateral border.

With the above described form occur teeth referable to the opposed position on the lower jaw, and which may have been associated with them. These teeth might readily be mistaken for worn examples of the mandibular posterior teeth of *Deltoptychius*, which they closely resemble in outline and contour of the coronal region. The specimen figured presents the usual appearance of the form, which has a triangular outline, the antero-lateral border slightly curved, with abrupt mural face, half or more of its height enveloped in the enamel belt which is distinctly defined from the slightly flaring basal rim; inner margin nearly at right angles with the anterior border, broadly arched in a slight sigmoidal course passing to the posterior angle; postero-lateral border, basal portion channeled and expanded behind. The principal lobe occupies something less than half the transverse diameter of the crown, presenting a nearly plane or slightly convex slope to the abrupt anterior edge, along which should lie the distinctly defined narrow, plain belt did these teeth belong to *Deltoptychius*, and where, indeed, in some specimens a faint depressed line does occur, a character in accordance with the homologous form of the latter genus; posteriorly the slope more abruptly descends into the wide posterior depression, along the outer border of which lies the rather suddenly upraised posterior wing. The surface presents a similar punctate appearance noted in connection with the before mentioned maxillary teeth. Breadth across inner margin, 5 mm; length of antero-lateral border to point of inrollment, about 5 mm.

The maxillary teeth above noticed present an approach to the straight postero-lateral border characteristic of *Orthopleurodus*; but here the resemblance ceases, for the border is gently arched, and the position of the posterior lobe, or rather the anterior culmination of its crest, determines its relations with the present genus, should it prove not to be referable to *Deltoptychius*. Their existence, however, is extremely suggestive of the derivation of the coal-measure genus, although there seems to be evidence that the present genus survived the introduction of *Orthopleurodus*, along with which its supposed representatives are found.

Compared with the previously described forms from the St. Louis limestone, *V. simplex*, there exists the most intimate relationship, if not actual specific identity, the chief distinction consisting in the apparent greater robustness of the present teeth.

With the above observations, until more complete materials shall have been acquired, the determination of the generic identity of these fragmentary dental remains will necessarily remain for the present in a state of uncertainty. So intimately are the species of *Vaticinodus*, *Stenopterodus* and *Deltoptychius* linked together, that it might be anticipated the more differentiated forms of *Orthopleurodus* may have had ancestors in direct line as early as the time when the sediments of the St. Louis and Chester formations were in process of deposition.

Geological position and locality: Chester limestone, upper fish-bed stratum; Chester and Evansville, Illinois.

VATICINODUS? CARBONARIUS, St. J. and W.

Pl. IV. Fig. 20.

Maxillary posterior teeth below medium size, irregularly oblong or subspatulate in outline, moderately arched from within outwards. Postero-lateral border somewhat rapidly converging from the acutely rounded posterior extremity to the point of inrollment, the narrow enamel fold inbeveled and distinctly defined from the rather widely expanded basal rim, which projects gently downward and outward beyond the coronal limits; antero-lateral border not preserved; inner margin apparently broadly and regularly arched, inbeveled inferiorly. Coronal prominence occupying half, perhaps more, of the crown surface, obscurely defined in front from the plane anterior area, gently arched transversely with the wider slope posterior of the low crest. Worn surface minutely and closely punctate.

The present species is recognized from a single specimen belonging to the left ramus of the upper jaw. Unfortunately it is mutilated, not displaying the character of the antero-lateral border, and the coronal surface is so disfigured by attrition as to obscure the original contour. Its relations, however, seem to be with the teeth arranged under the present generic formula, of which it is an interesting recurrence in the uppermost groups of the Carboniferous series. It is, however, possible that it may prove to be generically allied to *Stenopterodus*. Worn specimens of the corresponding form of the St. Louis species, *S. parvulus*, would indeed be difficult to distinguish from the present unique example.

Geological position and locality: Lower Coal Measures, roof of coal No. 5, of the Illinois general section, Carlinville, Illinois.

VATICINODUS? LEPIS, St. J. and W.

Pl. IV. Fig. 21.

Posterior tooth of the maxillaries of small size, subrhomboidal in outline. Antero-lateral border very oblique in forward and outward course, making a comparatively slight angle with the inner margin, which is broadly arched to the obtusely rounded posterior angle; postero-lateral border gently arched, converging toward the point of inrollment at an angle of 30°, more or less, with the opposite side, and parallel with the forward half of the inner margin, basal portion channeled, positively extended beyond the limits of the narrow inbeveled fold of the coronal enamel; the antero-lateral border similarly defined. Posterior lobe of the crown gently arched transversely, in front merging into the plane anterior surface from which it is apparently obscurely defined. Surface, along the inner margin preserving the dense enamel layer, with distinct lines of growth parallel with that margin; the worn triturating surface showing a minute punctate structure, the pores of extreme minuteness and relatively widely spaced. Greatest breadth across inner margin 9.5 m m, the basal spur extending a millimeter farther; length along antero-lateral border about 4.5 m m.

Only a solitary example of the present species is known to us. The coronal contour, although much worn by use, presents characteristics consonant with *Vaticinodus*, specifically differing from its Coal Measure congener *V. carbonarius*, by the relative great diameter in the direction of inrollment, the broad and uniformly arched inner margin, also the more obscure definition of the coronal prominence. The arched condition of the postero-lateral border, and the entirely dissimilar coronal contour distinguishes the tooth from the homologous form of *Orthopleurodus*, with which it is associated in the same deposits.

Geological position and locality: Upper Coal Measures; upper limestone at LaSalle, Ill.

GENUS DELTOPTYCHIUS, Agassiz.

Deltoptychius, Agassiz, MSS., 1859, etc., *D. (Cochliodus) acutus*, Ag.

Teeth possessing the general characteristics attributable to the family Cochliodontidæ.

Posterior teeth of the lower jaw trigonal in outline, generally strongly built, and moderately arched in the direction of inrollment. Antero-lateral border partaking of a slight sigmoidal curvature in consonance with the spiral inrollment of the tooth, defined by a nearly vertical wall forming at the brink a right angle with the superior crown surface, and enveloped to a greater or less extent in the coronal enamel which usually constitutes a slight inbeveled fold well defined from the basal portion; postero-lateral border more or less oblique to the opposite border, toward which it converges at the outer extremity, defined above by a shallow enamel fold, beneath which the basal rim projects downward and outward, terminating posteriorly in a more or less produced spur; inner margin broadly rounded or sigmoidally curved from the obtuse anterior angle into the more acute extremity of the posterior wing. Coronal contour presenting three divisions, all regularly narrowing toward the outer extremity, viz: In front, a narrow transversely plane belt; a more or less prominent median ridge defined in front by a slight angulation from the anterior belt, and sloping posteriorly into the broad depression from which rises the more or less laterally expanded posterior wing,—well preserved teeth also showing a slight angulation on this side of the median lobe where it joins the posterior depression.

Posterior teeth of the upper jaw subspatulate in general outline, terminating posteriorly in an acute angle or spur, antero-lateral border truncated generally obliquely outward and backward, strongly inrolled along the outer margin for two-thirds the distance from the anterior extremity. Crown defined from the base by a shallow inbeveled fold along both the antero—and the postero—lateral borders, the basal portion in front nearly vertical or somewhat channeled, projecting downward and outward behind where it forms the spur at the extreme posterior angle. Coronal region showing a depressed posterior prominence, in front of which less or more remote, a smaller secondary ridge, separated by a plain intervening furrow, and having an oblique course from the within outward in conformity with the direction of inrollment; anterior neck generally smooth, destitute of marked revolving ridges or furrows, and gradually contracting toward the truncate anterior border, where the vertical depth of the tooth is at the minimum, in consequence of which the anterior border is extremely liable to mutilation as is shown by the rarity of entire examples of this form.

The maxillary posterior form is immediately succeeded in front by at least one series of teeth, consisting of transverse coronal ridges, which together present a trapezoidal outline, the postero-lateral border articulating with the posterior tooth nearly straight and forming a right or obtuse angle with the inner margin, antero-lateral border more or less obliquely converging towards the outward extremity. The coronal ridges present a series of parallel crests, vertically convex behind and concave in front, which in general possess to some extent characters in common with certain forms of teeth, which have been variously referred to the genera *Helodus* and *Chomatodus*.

Coronal surface presenting the usual enamel coating; worn surfaces punctate.

The various forms of teeth constituting the dentition of *Deltoptychius* have been in all cases recognized from isolated detached specimens, save in the instance of the maxillary posterior and median serial teeth. In the latter we have authentic evidence of specific identity, in the discovery by Mr. Wachsmuth of a specimen showing the teeth in actual material juxta-position. Wherever the one form occurs there also is found the others, and taking this fact into consideration and what is known of the various forms of teeth belonging to the genera *Cochliodus, Orthopleurodus,* etc., the association here conjectured seems to be amply warranted. The genus as here defined bears intimate relationship with *Cochliodus* and *Chitonodus,* holding an intermediate position between the latter and *Vaticinodus* and *Stenopterodus.* It is, however, distinguished from the former by peculiarities in the coronal contour of the maxillary posterior teeth, and the greater obliquity cuneate outline of the mandibular posterior form, but chiefly in the character of the enameled abrupt antero-lateral border of the latter form, which in *Cochliodus* presents a narrow fold precisely like that along the postero-lateral border, also as occurs in either lateral border of the maxillary posterior form. This, in view of the uniformity of the articular borders in the variforms of *Cochliodus, Chitonodus* and their intimate allies, might be regarded as inconsistent with the conjectured association of forms in the present generic group of teeth. But after all it seems in some sort to foreshadow or form a transition from the true *Cochliodus* type to that of *Pœcilodus,* the mandibular posterior form of which possesses much the same character of steep enameled antero-lateral border as obtains in the homologous form of the present genus; in both of the latter genera the articular border of the opposed maxillary form partakes still to a most intimate degree of the character of typical *Cochliodus.*

The genus is apparently confined to the measures of the Lower Carboniferous period, representative species occurring in each of the successive formations beginning with the Upper Burlington, and includes the form described by Dr. Leidy under the name *Cochliodus nitidus,* of the Chester formation.[1]

According to the above interpretation of the facts, the genus possesses precisely similar diagnostic terms distinguishing the form referred by authors to the "anterior" tooth of *Deltoptychius acutus,*

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[1] **Trans. Am. Phil. Soc.,** vol. XI, p. 87, Pl. v, f. 2.

Agass., of the Mountain limestone of Ireland; and almost to the same degree the maxillary posterior form named *Streblodus Colei*, Agass., MSS., 1859, from the same deposits. The so-called "terminal" tooth, which authors have associated with the first named form, is strictly more intimately related to *Pœcilodus*, and is homologous with the mandibular posterior form, as shown by the alate postero-lateral border, and although destitute of transverse undulations or imbrications, it partakes in a marked degree of the coronal conformation distinguishing the latter genus. Hence we are strongly impressed with the conviction that the two forms heretofore associated under the designation *D. acutus* pertain to quite distinct generic categories, and that there exists strong probability of the generic identity with the present forms of the teeth referred to under the term *Streblodus Colei*, and their possible specific identity with the mandibular posterior (so-called "anterior") teeth of *D. acutus*. The typical form of *Streblodus Colei*, however, presents distinctions which might readily be regarded as emphasized specific variations, as compared with the maxillary posterior form of *Cochliodus contortus*, Agass., (*Streblodus oblongus*, Agass.); and at the same time it presents an extreme departure from the normal characters distinguishing the same form which is here ascribed to representative American species of *Deltoptychius*. From the latter the Irish form is distinguished by the considerable breadth of the depressed interval separating the narrow secondary lobe from the posterior coronal prominence and the consequent relatively narrower anterior neck, which latter is nearly plain and terminated precisely as above described. It will, therefore, be observed on close inspection of the Irish and American forms that, while they differ in the above respect, they are more intimately related to one another than the former is with the maxillary posterior tooth of *Coch. contortus* (*Streb. oblongus*,) and it is on these grounds we have been led to suggest its generic identity with *Deltoptychius*, as herein amended. The Irish form referred by authors to the "terminal" tooth of *Deltoptychius*, is not met with in this country, unless, as has already been mentioned, it should be regarded as identical with the mandibular form of *Pœcilodus*. We are, however, not aware that the Irish localities have afforded other *Pœcilodus* forms which might be specifically identified with the latter.

DELTOPTYCHIUS PRIMUS, St. J. and W.

Pl. V. Fig. 6-8.

The dentition of the earliest known species of *Deltoptychius* is represented in the collections by a few imperfect, fragmentary examples of the posterior forms of the upper and lower jaws, which attain medium size. The mandibular teeth may be distinguished in the examples before us by the obscurer definition of the median prominence from the narrow belt in front, and shallow depth of the enameled abrupt antero-lateral border. The opposed teeth of the upper jaw appear to have had the principal posterior prominence relatively more convex transversely, producing a more rounded outline in this part of the inner margin than obtains in the representative Keokuk species. In the proportionate prominence of the secondary lobe, the present teeth bear greater resemblance to the corresponding form occurring in the Warsaw limestone, from which, however, they differ in the greater convexity of the posterior prominence. In size the above noticed teeth are uniformly below that attained by the allied forms in the Keokuk limestone, holding in this particular an intermediate position between the latter and the Warsaw species.

The examples of the above noticed forms thus far known, chiefly from discoveries of Mr. Springer and Mr. Wachsmuth, are few, and unfortunately in a very imperfect state of preservation, owing to the friable nature of the mineralized dental substance; and while the material is insufficient to enable a detailed description of the teeth, it affords ample evidence of the generic relations, as also indicating the characteristics by which they may be contrasted with congeneric forms.

Geological position and localities: Upper Burlington fish-bed; Buffington creek, and Augusta, Iowa.

DELTOPTYCHIUS WACHSMUTHI, St. J. and W.

Pl. V. Fig. 1-5.

Teeth attaining medium size. Mandibular posterior form triangular in outline, sigmoidally curved along the inner margin, terminating in front in a narrow, inrolled beak; postero-lateral border gradually converging toward the outer extremity, showing a deep, nearly vertical basal border, slightly inclined outward, and expanded toward the posterior angle, and marked above by the narrow enameled fold which is defined from the basal portion by a slight channel; antero-lateral border forming a vertical face at the inner angle, gradually sloping upward and backward toward the outer extremity, and, save a narrow belt along the inferior edge, enveloped in the enamel fold, which is also well defined from the basal rim. Coronal region traversed longitudinally by a moderately prominent, transversely arched median ridge, the axis of which lies nearest the antero-lateral border, and sharply defined on either side by an angulation or narrow groove; anterior belt relatively narrow, very faintly arched transversely, or nearly plane, and scarcely half the width of the median-lobe; posterior alation about the same width as the median-lobe, transversely concave and merged into the posterior depression from which it steeply rises into the produced posterior angle. Surface finely punctate. Greatest length of tooth along postero-lateral border, 40 mm.; ditto, antero-lateral border, 30 mm.; breadth across inner margin, 23 mm.; greatest height of antero-lateral border, 8 mm.

Maxillary posterior teeth subspatulate in outline, strongly from within outwards, outer margin strongly inrolled; postero-lateral border making a broad curve outward and forward from the obtusely pointed posterior angle to point of inrollment, thence to the anterior angle the outline is slightly concave; inner margin arched round the base of the coronal prominence, and thence nearly straight to the anterior border; antero-lateral border slightly obliquely truncated from the inner to the outer angle, and equal to about two-thirds the diameter of the tooth along a line diagonal to the direction of inrollment across the posterior ridge. Posterior lobe of the crown occupying little more than one-third the total breadth of the tooth, moderately arched transversely, the crest culminating in front where the surface rapidly descends into the narrow furrow defining it from the subordinate ridge, which latter presents a nearly uniform convexity, gradually narrowing from within outward, and, in perfect specimens, defined in front by a distinct though slight angulation; anterior neck nearly smooth, with a few obscure rugose lines along the inner margin, destitute of revolving ridges. Breadth of a medium-size tooth between the inner angles, 48 mm.; breadth of tooth across the posterior prominence diagonal to the inrollment, 20 mm.; length along antero-lateral borders, 13 mm.

Maxillary median teeth forming a triangular plate articulating with the posterior tooth by the straight postero-lateral border, the oblique antero-lateral border rapidly converging toward the outer extremity, which presents the same degree of inrollment observed in the preceding posterior form. Coronal region presenting a series of transverse ridges, which individually possess coronal characters ascribable to certain forms of *Helodus*, a medium-size specimen showing five such coronal ridges, whose longer axes correspond to longer diameter of the posterior tooth. The individual ridges rise in an even convex surface behind, culminating in an obtuse even crest, the outer face moderately concave vertically, and invested in the enamel layer, save along the crests, which reveal the relatively coarse punctate structure. Breadth of series across inner margin 10 m m.; length along postero-lateral border 11 m m., corresponding to that of the anterior border of the posterior tooth. The proportionate dimensions of the individual coronal ridges are represented in the illustrations.

Of the forms above noticed and associated under the same specific designation, the collections contain a fair suite of representatives, amongst which the teeth referred to the posterior position upon the lower jaw are in about double the numbers of those belonging to the maxillaries; while of the small anterior, or median dental series of the upper jaw, only a single specimen is known—that discovered by Mr. Wachsmuth, at Danville, Iowa. With regard to the latter, the resemblance it bears to *Helodus elytra*, N. and W., of the same geological horizon, creates a suspicion of the specific identity of similar Helodus-like teeth with the form here alluded to. The original specimen of *Helodus elytra*, however, apparently shows a series of independent, contiguous teeth, in their relative natural position, but with their coronal crests worn down almost even with the basal margins, so that it is impossible to determine the coronal contour, although, as has been stated, we strongly suspect the form is identical with teeth, perfect specimens of which have been described under other designations. The consolidation along the basal impingement of the separate teeth is precisely what has been noticed in connection with other allied forms of this family, and although a matter of biological interest and importance, it should not militate against the recognition of the specific identity of series of isolated teeth and those that are joined by their bases into a solid dental plate, as is the case in the above form.

The maxillary posterior teeth are seldom preserved entire, and the attenuation of the anterior region exhibits unmistakable evidences of the excessive attrition these teeth were subjected to during the life of their possessors. In some specimens, as that discovered by Mr. Wachsmuth, the abraded anterior coronal region presents a coarse, irregular punctate structure, characteristic of the vaso-dentine composing the body of the teeth. In mature and much-worn teeth—where the enamel and outer subjacent layers have been removed by the process of attrition—a similar exposition of the coarse, tubular structure is laid bare all round the inner and outer margins of the tooth; in other examples the abrasion has been carried so far as to produce a deep channeling of the surface of the posterior prominence in the direction of the long, or transverse diameter of the tooth; and in those that preserve the crown surface in a perfect state, the enamel along the inner margin, through which the minute, prismatic structure is visible, shows distinct parallel incremental lines, more or less sharply impressed, and even reaching well up over the crown, producing an irregular, undulated surface, extending alike over the posterior prominence and the anterior neck. In well-preserved specimens the secondary lobe in front of the principal coronal prominence is defined with absolute distinctness. The posterior angle probably terminated in a more or less produced spur, the enamel apparently forming a narrow fold enveloping the superior edge of the antero-lateral border, similar to what obtains in corresponding teeth of *Cochliodus;* however, in some specimens this border is slightly raised into a low, obscurely-defined marginal ridge.

The mandibular posterior teeth, also, exhibit much the same superficial features due to the various conditions of usage and preservation as enumerated in connection with the teeth of the opposite jaw. The anterior plane-belt is usually merged into the median prominence toward the outer margin, the result of wearing down of the crown surface; but toward the inner margin the coronal contour is well, even sharply defined, the surface enveloped in a layer of polished enamel.

Geological position and localities: Keokuk limestone: Warsaw, Hamilton, Nauvoo, and Henderson county, (Illinois); Keokuk, Danville, Bentonsport, (Iowa); Booneville, (Missouri).

DELTOPTYCHIUS VARSOVIENSIS, St. J. and W.

Pl. V. Fig. 14, 15.

Mandibular posterior teeth trigonal in outline, apparently strongly inrolled at the outer extremity, inner margin very oblique and broadly rounded with slight sigmoidal curvature, postero-lateral border rapidly converging toward the outer extremity. Median ridge of crown prominent, occupying a nearly central position and well defined from the relatively wide anterior belt, which latter presents the characteristic angulation and abrupt face enveloped for the greater part of its depth in the coronal enamel; posteriorly the slope of the median ridge descends into the broad depression on that side, from which rises the relatively wide posterior expansion or alation. Crown surface densely punctate. A specimen below medium size measures in greatest length from posterior angle to outer extremity about 11.5 m m.; antero-lateral border about 6.5 m m.; breadth at inner margin 8 m m.

Posterior tooth of upper jaw of the usual spatulate outline, antero-lateral border obliquely truncated from inner angle forward to outer angle, posterior extremity somewhat produced from which the postero-lateral border somewhat rapidly converges toward point of inrollment. Posterior prominences occupy half, or a little more, of the coronal area, secondary lobe about one-third the dimensions of the principal ridge, from which it is separated by a deep furrow, and well defined in front from the apparently smooth anterior area which gradually contracts towards the anterior border. Superficial punctation agreeing with that described above. A mature specimen measures in greatest diameter across the inner margin 17 m m.; greatest breadth across posterior prominence 7 m m.; length along antero-lateral border 4.5 m m.

The present species is made known from a single representative each of the posterior form pertaining respectively to the upper and lower jaws. Neither of these examples is entire, although they are sufficiently so to permit of a not unsatisfactory comparison with other generically allied forms. The species is most intimately allied to that occurring in the St. Louis formation, *Deltoptychius expansus;* especially is this relationship apparent in the close resemblance that exists between the maxillary posterior forms of the two species. It differs, however, from the latter species in a marked degree in respect to the coronal contour of the mandibular posterior teeth, which shows the median ridge well developed and defined from the narrow belt in front and the much greater obliquity of the inner margin of the tooth.

Geological position and localities: From characteristic strata of the **Warsaw formation**; Clifton, above Alton, and Golden Bluffs near **Warsaw, Illinois.**

DELTOPTYCHIUS EXPANSUS, St. J. and W.

Pl. V, Fig. 9, 13.

Posterior teeth of the mandibles, trigonal in general outline, outer extremity strongly inrolled, relatively broadly expanded posteriorly, and broadly arched along the inner margin with sigmoidal curvature in passing to the posterior extremity of the strong wing expansion. Antero-lateral border slightly curved sigmoidally, moderately deep, the greater portion of the vertical face being covered by the coronal enamel and making a well-defined angulation above; postero-lateral border rapidly converging toward the extremity, basal portion projecting somewhat beyond the narrow and prominent fold limiting the coronal surface, and more or less produced posteriorly. Coronal surface showing a broad, deep posterior depression, which, together with the alate border, constitutes half the lateral diameter of the tooth; median lobe relatively narrow, generally obscurely defined in front from the narrow anterior plane belt with which it is usually merged over the greater extent of the outer surface. Length of a medium-size tooth along antero-lateral border 8 mm.; breadth at inner margin 8.5 mm.

Posterior tooth of the upper jaw in outline spatulate, terminating posteriorly in an eccentric sharply rounded spur, antero-lateral border obliquely truncated from inner angle outward and forward. Coronal prominence comprising nearly two-thirds the transverse diameter of the tooth, posterior lobe moderately convex transversely, subordinate lobe relatively broad and prominent, anterior area smooth, and narrowed toward the antero-lateral border. Surface minutely and closely punctate, in the same manner observed in the opposed teeth. Greatest transverse diameter of a medium-size tooth about 12 mm.; greatest diagonal breadth across the posterior prominence 5 mm.; length along antero-lateral border 4.5 to 5 mm.

Of other dental forms occurring with the above described teeth, none have been recognized as probably specifically identical. In superficial coronal characters, as the punctation and appearance of the enamel layer, the two forms above noticed possess most intimate characters in common, so that, notwithstanding the fact that all the material in our possession consists of isolated teeth, little doubt is entertained as to their having constituted parts of the dentition of the same species.

Compared with the Keokuk species, *D. Wachsmuthi*, the present teeth present well-marked differences which serve to distinguish them specifically. The mandibular posterior teeth are proportionately shorter from within outward and wider across the inner margin, and the median-lobe perhaps less well defined from the narrow anterior belt; while the opposed tooth of the upper jaw has the secondary lobe relatively much more strongly developed and the coronal prominence occupying a greater portion of the crown surface.

The state of preservation of these diminutive teeth, especially in the instance of those pertaining to the mandible, is extraordinary. But of the maxillary teeth the collections afford few examples, and these are without exception mutilated at the antero-lateral border, in consequence of the extreme although not disproportionate attenuation they undergo in that region.

Geological position and localities: St. Louis limestone; Alton and Monroe county, Ill.; Pella, Iowa; St. Louis, Mo.

DELTOPTYCHIUS NITIDUS, (Leidy, sp.)

Pl. V, Fig. 16.

Cochliodus nitidus, Leidy, 1856. Trans. Am. Phil. Soc., xi, p. 87. Pl. v, f. 2.

The present species was originally described by Dr. Leidy, from a large-sized specimen of the posterior tooth of the left ramus of the lower jaw, which was obtained at Chester, in this State. The teeth are massive, and strongly built, triangular in outline, postero-lateral border rapidly converging toward the outer extremity, inner margin broadly curved round the base of the median prominence, antero-lateral border nearly straight, relatively short, the enamel fold extending well down over the abrupt face. The basal portion along the postero-lateral border, in a mature individual like the type noticed by Dr. Leidy, extends in a conspicuous rim beyond the well-defined enamel fold, terminating in a strong, bony spur, posteriorly, and reaching the point of strong inrollment, where it presents the usual channeled condition. The crown is strongly arched from within outward, median lobe embracing about half the lateral diameter of the crown, usually prominently arched transversely, a slight angulation defining it from the narrow anterior belt, the slope behind descending into the posterior depression, which is bordered by the relatively narrow alation. A medium-sized tooth measures, along the postero-lateral border from the posterior angle to point of inrollment, 12 mm.; length along antero-lateral border, 7.5 mm.; breadth across inner margin, 10 mm.

The collections contain examples of maxillary posterior teeth, from the same deposits and localities, associated with the above described teeth, which probably belonged to the same species. The latter, however, are in so worn and mutilated a state of preservation as not to exhibit details beyond mere outline, by which they may be satisfactorily compared with other specimens of the same form.

The loan of the type was kindly procured us by Dr. Leidy, a careful comparison of which with the material before us leaves not the least doubt as to their specific identity. The species, as represented by the posterior teeth of the mandible, is intimately allied to *D. expansus*, of the St. Louis limestone, being chiefly distinguished by its more robust figure, stronger inrollment, and narrower posterior alation. The majority of the examples of this form exhibit traces of excessive coronal abrasion, which in some instances has leveled the median prominence, destroying its definition from the plane anterior belt, in which latter condition the individuals bear deceptive resemblance to the homologous teeth of *Orthopleurodus*.

Geological position and locality: Chester limestone; Chester, Ill.

GENUS STENOPTERODUS,[1] St. J. and W.

Teeth, probably occupying a posterior position on the upper jaw, distinguished by their long-elliptic outline, strongly arched and spiral inrollment of the outer extremity. Crown traversed by a posterior prominence or lobe in the direction of inrollment, more or less well-defined from the anterior area, which presents a plane surface, without prominent revolving or longitudinal folds; posteriorly, the crown is well defined from the base by the inbeveled enamel fold, beyond which the basal rim usually more or less projects, often terminating in a strong posterior process, and forming, in well-preserved specimens, a deep border toward the inner margin, becoming less conspicuous outwardly; anteriorly truncate, usually more or less obliquely so from the inner angle outward and backward to point of inrollment (though sometimes outward and forward from an obtuse inner angle), the shallow enamel fold inbeveled and defined by a narrow sulcus from the base. Surface of crown in perfect state covered by a dense enamel-like, glossy coating, through which the tubular structure presents a delicate papillose appearance; worn surfaces minutely and densely pitted by the exposed extremities of the medullary tubes; vaso-dentine of base coarse, inferior surface of the dense inferior layer irregularly striated in the direction of inrollment.

NOTE. 1. *Stenos*, narrow; *pteron*, wing; *odous*, tooth. In allusion to the narrow alation of the mandibular posterior tooth

The above diagnosis applies to a certain form of teeth well represented in the collections from various Lower Carboniferous formations, and which is homologous with the long posterior teeth of the upper jaw, formerly embraced under the generic term *Streblodus*, Agass. Since it is now a well established fact that the latter form formed part of the dental armament of the jaws of the same fish that bore the teeth represented by the original form of *Cochliodus*, Agass., there can scarcely arise a question as to the position the present form held upon the jaw.

It may, perhaps, be deemed premature at the present time to attempt the identification with the above form of other and associate teeth from amongst the detached dental remains of Cochliodonts, alone contained in the collections; but there are certain forms whose occurrence and intimate association in the same deposits with that above noticed, strongly suggest their congeneric relations and specific indentity. Thus, there are found teeth which, possessing the general characteristics attributed to the large posterior teeth of the mandible of *Cochliodus*, may be especially characterized by their more trapezoidal outline, posterior position of the median lobe, narrow posterior alation, and the relatively broad flat area of the neck or anterior portion of the coronal region. The latter form is further distinguished by the greater or less obliquity of the outward and backward course of the antero-lateral border, which, together with the postero-lateral border, presents the same condition of narrow, rounded, inbeveled enamel fold and channeled basal rim observed in connection with the opposite maxillary teeth, with which they also agree in the degree of inrollment and longitudinal convexity of the coronal region. The neck or anterior area is nearly plane or faintly swollen transversely, sometimes with a slight depression near to and parallel with the antero-lateral border. The posterior alation is narrow and separated from the median lobe by a comparatively narrow depression. The inner margin is moderately concave in passing the posterior depression, broadly arched round the base of the coronal prominence, and thence to the anterior angle more gently curved or nearly straight. The relative proportions of the teeth are laterally narrower and stouter than the maxillary posterior form.

There are associated with the two most numerously represented species of the genus a form of teeth, which from their general appearance and apparent identity of coronal structure, we have presumed to identify with the mandibular median form of the present genus. The latter teeth are subrhombic or trapezoidal in outline, with a nearly straight postero-lateral border, and longer and more obliquely converging opposite border, defined by the same style of enamel fold and basal rim, characteristic of the previously mentioned forms; the coronal region presents a broad, nearly plane surface, gradually culminating near the postero-lateral borders in a depressed, obscurely defined ridge, where the slope to the border on the one hand is abrupt, and on the other very gentle, the inner margin gently arched and somewhat rapidly deflected to the obtuse posterior angle.

The genus as now understood is represented by species beginning in the Upper Burlington limestone, and in each succeeding formation of the Lower Carboniferous period, the latest authentic occurrence being in the St. Louis limestone.

STENOPTERODUS PLANUS, St. J. and W.

Pl. IV, Fig. 9 14.

Represented by two forms of teeth below medium size, presumably occupying corresponding positions on opposite jaws.

Posterior teeth of the upper jaw sub-rhomboidal in outline, rather strongly inrolled and arched longitudinally. Antero-lateral border slightly oblique in its forward and outward course, basal rim apparently shallow, and defined from the narrow enamel fold by a shallow groove; postero-lateral border converging at an angle of about 25 with the opposite border, the basal rim somewhat thickened and produced beyond the limits of the narrow, inrolled enamel fold, inner margin broadly arched with a slight angulation near the middle in passing the base of the coronal prominence, in front of which a sharp, slight constriction occurs, the inferior edge inbeveled in the worn condition; posterior extremity forming a sub-acute angle, the margin making an obtuse angle with the anterior border. Coronal prominence comprising more than half the lateral area of the surface, culminating in a low, rounded crest near the median line, with an abrupt slope to the anterior neck, defined by an intervening shallow groove, the posterior broad slope very gently and faintly depressed transversely; the anterior neck somewhat rapidly narrows to the antero-lateral border, is gently convex transversely and marked by faint, longitudinal plicæ. The whole outer third or more of the crown surface presents an even, smooth, triturating area, the result of wear, exposing to view the minute, regular punctæ, which usually show marked tendency to elongation in the direction of the inrollment of the tooth; the inner surface shows a dense layer of enamel with fine lines of growth parallel with the inner margin. Greatest transverse diameter of the tooth, 20 mm.; length along antero-lateral border, 6.5 m m.; greatest longitudinal diameter, 10.5 mm.

Posterior tooth of the mandible sub-quadrangular in outline, rather strongly inrolled and longitudinally arched; corresponding in size with the previously-noticed form. The moderate and regular arching of the inner margin interrupted by the broadly-rounded base of the coronal prominence; antero-lateral border with a slight oblique course outward and backward, enamel fold relatively deep and inbeveled to the shallow, channeled basal rim; postero-lateral border very gradually converging, making an angle of 10° or 15° with the opposite side, the narrow enamel fold well defined from the basal portion, which forms a shallow rim projecting considerably beyond the limits of the crown. Median prominence regularly and broadly arched transversely, culminating a little posterior of the median line, and occupying quite half of the lateral diameter of the crown; posteriorly, the slope merges into the shallow concavity bordered exteriorly by the gently-upraised alation, in front defined by a faint angulation from the wide, slightly convex belt intervening between the median lobe and the antero-lateral border. The surface of the anterior belt is marked by faint, revolving plicæ, and along the inner margin the enamel coating shows more or less distinct parallel undulations, or lines of growth, the outer half of the coronal surface exhibiting the usual evidences of excessive trituration, the entire coronal area minutely and closely punctate, the punctæ showing the longitudinal elongation precisely after the manner observed in connection with the opposed maxillary teeth. Breadth across inner margin, 17 mm.; longitudinal diameter along the axis of median lobe, 9.5 mm; length along antero-lateral border, 7 mm.

The two forms of teeth described above are represented in equal numbers in the collections, and their uniform association and agreement in size and superficial characters preclude any doubt as to their specific identity. As commonly occurs in the teeth of this family, in consequence of the attenuation of the borders, seldom is a specimen met with showing the antero-lateral border entire, and indeed in the majority of examples of the mandibular form the posterior wing or alation is also mutilated or broken away.

Teeth supposed to represent the median form of the mandibles, small, trapezoidal in outline, strongly arched from within outward. Postero-lateral (?) border nearly straight, with slight obliquity in its outward and slightly forward course, basal portion evidently shallow, channeled, and defined above by the relatively strong, rounded enamel fold: antero-lateral or oblique border converging from the sub-acute inner angle to point of inrollment at an angle of about 20 with the opposite border, the strong, rounded enamel fold projecting beyond the comparatively shallow, channeled basal rim: inner margin somewhat abruptly rounded from the obtuse posterior angle, thence nearly straight to the anterior angle, usually inbeveled inferiorly. Coronal surface showing a wide, gently depressed acclivity very gradually rising from the antero-lateral border culminating in a rounded ridge, the posterior slope of which abruptly descends to the postero-lateral border fold, from which it is defined by a narrow parallel depression. The latter feature may become obsolete in worn specimens--indeed the whole outer half of the coronal surface usually bears evidences of excessive wear from use. The inner margin of the crown preserves the enamel coating, through which the somewhat irregular orifices of the tubular structure are distinctly discernible, worn surfaces showing a fine pitted structure with the longitudinally elongate punctæ exactly as remarked in the before mentioned forms. A medium sized tooth measures in greatest diameter between the inner angles 7.5 mm; length along postero-lateral border to point of inrollment nearly 4 mm.

In assigning the last above described form to *Stenopterodus*, we have been guided chiefly by the marked resemblance of the surface punctation to that observed in the posterior forms of the upper and lower jaws with which it is associated in the same deposits. But while the above forms are represented by several individuals each, the collections contain only three examples of the present form, and two of these are proportionately much smaller than any of the examples of the mandibular posterior teeth with which it is supposed this form was specifically associated; but Mr. Springer's collection contains a single imperfect specimen of a larger individual which corresponds in relative size to the ordinary dimensions of the mandibular posterior teeth.

In general outline and coronal contour these teeth bear some resemblances in common with the forms provisionally identified with the mandibular median teeth of *Sandalodus*, etc. They are, however, in this case distinguishable by the abrupt posterior declivity of the coronal prominence and its distinctly defined border fold of that side.

Geological position and localities: Upper Burlington fish-bed; Burlington, Buffington Creek, Augusta, Pleasant Grove, Iowa; Quincy, Honey Creek, Henderson county, Illinois.

STENOPTERODUS, sp.?

Pl. IV, Fig. 15, 16.

Posterior form of the upper jaw below medium-size, sub-elliptical or spatulate in outline, moderately arched, longitudinally and strongly inrolled along the outer margin. Antero-lateral border comparatively short, with slight obliquity outward and forward; postero-lateral border gently arched, and rapidly converging from the acutely rounded posterior extremity toward point of inrollment, making an angle of 30°, more or less, with the anterior border; inner margin gently and regularly arched, inbeveled inferiorly. Coronal region presenting a low prominence, the obscurely defined axis culminating about the middle of the tooth, flanked on one side by the wide, nearly plane slope descending to the postero-lateral border, on the other by a narrower, perceptibly steeper declivity, which merges into the relatively narrow, plane anterior neck. Surface minutely and closely punctate, the punctæ showing quite regular disposition in parallel longitudinal lines. Breadth across inner margin 14 mm.; length of antero-lateral border about 4.5 mm. Mandibular posterior tooth proportionately corresponding with the opposed maxillary form, trapezoidal in outline, rather strongly arched and inrolled. Inner margin somewhat strongly arched round the base of the coronal prominence, moderately so to the anterior angle, and slightly concave in passing the posterior depression toward the extreme angle; lateral borders not definable. The coronal ridge is strongly convex transversely, occupying apparently quite half the lateral area of the crown, posterior depression well marked and regularly concave transversely, the anterior belt defined by a faint angulation, apparently plain. Surface punctation precisely as observed in connection with the maxillary posterior form, the punctæ being slightly compressed laterally, emphasizing the linear longitudinal arrangement.

The above diagnoses are based upon unique examples in each instance, the former preserving scarcely more than the outline and the excessively worn superficial contour, the latter showing only the central portion of the tooth, the mutilated borders not displaying the outline of the tooth. They furnish a singular instance of the paucity of certain fish-remains in the collections from a formation which has yielded rich and varied materials pertaining to allied genera. The teeth certainly, so far as it is possible to carry the comparison, offer striking resemblance to the corresponding forms occurring in the superjacent Warsaw limestone, *Stenopterodus elongatus*, in outline, apparently coronal conformation, and the character and disposition of the punctæ. We should, therefore, be prepared to recognize their specific identity with the latter forms were the characters noticed in connection with the sole examples as yet known to us from the Keokuk horizon, shown to be persistent and normal in even a small suite of perfect specimens.

Geological position and locality: Keokuk limestone, fish-bed; Warsaw and Hamilton, Illinois.

STENOPTERODUS ELONGATUS, St. J. and W.

Pl. IV, Fig. 1-3.

Maxillary posterior teeth small, elliptical in outline, considerably arched and strongly inrolled along the outer margin. Course of antero-lateral border nearly at right angles to the transverse axis of the tooth, opposite border gradually converging from the obtusely-pointed extremity toward point of inrollment, neither border sufficiently well preserved to show details of enamel fold and basal rim. Coronal prominence relatively very broad, or occupying two-thirds the lateral diameter of the tooth, abruptly beveled along the postero-lateral border, broadly and regularly arched transversely, culminating anteriorly where it is defined by a slight declivity having a very oblique course toward the outer extremity; anterior area relatively narrow, quite smooth, plane, and nicely rounded in a narrow fold along the border, which is defined by a narrow sulcus from the shallow basal rim. Coronal surface minutely and finely punctate, the punctæ exhibiting a somewhat marked tendency to linear longitudinal disposition, and in mature examples the enamel shows distinct parallel lines of growth following the broadly rounded curvature of the inner margin. Greatest diameter of a small-sized tooth, 15 mm.; greatest diagonal breadth near middle, 6 mm.; length along antero-lateral border, 4 mm.

Posterior tooth of the lower jaw known only from very imperfectly preserved examples, which, however, shows a rather prominent and regularly arched median lobe, situate nearly centrally, with apparently well-developed posterior wing, nearly equalling in breadth the plane anterior area.

The above described species is represented in the collections by only a few examples, and in only two exceptions are the complete outline and coronal contour shown. From these we are led to recognize distinctive peculiarities that readily distinguish the teeth from congeneric forms previously noticed, with the exception in favor of the possible identity of the Keokuk forms with the present species.

Geological position and locality: Warsaw limestone; Golden Bluffs, near Warsaw, Illinois.

STENOPTERODUS PARVULUS, (N. and W. sp.)

Pl. IV, Fig. 4-8.

Sandalodus parvulus (in part), Newberry and Worthen, 1866, Ill. Geol. Surv., II, p. 102, Pl. X, f. 1.

The recognition of the above cited species was based upon a unique, nearly perfect tooth, representing the posterior form pertaining to the upper jaw. The specimen is mutilated along the outer margin in front, the inrolled extremity being broken away. The figure, however, conveys a very inadequate impression of the coronal contour, the engraving exaggerating the accidental features traceable to attrition at the expense of the natural contour surfaces. The specimen exhibits the posterior lobe of the crown, gradually culminating anteriorly, where it is suddenly broken down and defined by a slight depression from the plane anterior area with which it merges in the middle outer region of the coronal surface, where the tooth has been subjected to excessive attrition while in use. In the outward and forward obliquity of the antero-lateral border, also in the distinct definition of the shallow enamel fold along the still more oblique and gently arched postero-lateral border, where the basal portion forms a prominent rim, reaching to the point of inrollment, the original figure above cited conveys a more accurate idea of the form.

The acquisitions of Mr. Van Horne include a beautiful series of the above mentioned teeth, with which are associated, equally numerous, another form, which we have come to regard with a strong degree of probability as pertaining to the mandible of the species. The latter teeth exhibit in a marked degree homologous relationship to *Cochliodus*, possessing the same general outline and coronal contour distinguishing the large posterior teeth of the mandible of that genus, characterized, however, in accordance with the distinctive peculiarities appertaining to the present genus. The latter form is trapezoidal in outline, and in the arching and inrollment of the tooth it agrees with the opposed form; posterior wing narrow, basal rim extending conspicuously beyond the limits of the shallow, rounded, inbeveled enamel fold; median lobe situateda a little posterior of the middle, broadly and regularly arched transversely, culminating in a tumid crest, the slope on the one hand merging into the posterior depression, on the other defined by a slight angulation from the anterior area, which presents a broad plane or gently-convex surface, with faint impressed furrow near the border and nearly equal in breadth to the median lobe; antero-lateral border quite obliquely truncated outward and backward from the sub-acute inner angle; the inner margin is gently arched between the angles, somewhat more strongly arched around the base of the median prominence, and slightly deflected on nearing the posterior extremity. The external enamel coating investing the inner portion of the crown shows distinct lines of growth parallel with the inner margin, the worn surface regularly and minutely punctate, precisely after the manner observed in the opposite teeth of the upper jaw.

A medium-size posterior tooth of the upper jaw measures, in transverse diameter across the inner margin, 12.5 mm.; length along antero-lateral border to point of inrollment, 4 mm.; greatest diameter diagonal to the longitudinal axis, 5.5 mm. A large-sized mandibular posterior tooth measures, across the inner margin, 15.5 mm.; length along antero-lateral border, 7 mm.; longitudinal diameter, at middle 9 mm.

Mr. Van Horne's collection contains a single minute specimen of a tooth which clearly belongs to the form which we have already recognized from the Upper Burlington fish-beds, from examples in the collection of Mr. Springer, and which is referred to the mandibular medium form of *Stenopterodus*. The present tooth presents the same resemblances in surface punctation, as compared with the posterior forms of *S. parvulus*, as in the former instance was noted in connection with this form and *S. planus*. The latter specimen attains a breadth across the inner margin not exceeding

3.5 m m., and length along the straight postero-lateral border about 2 m m. Trapezoidal in outline, it is relatively broader than the Upper Burlington teeth of the same form; the postero-lateral border shows a slight forward obliquity in its outward course, basal portion exceedingly attenuated; antero-lateral borders converging toward point of inrollment at an angle of about 30° with the opposite border, too imperfect to show the character of the basal rim beneath the narrow, enamel fold: inner margin very gently arched from the anterior angle, and abruptly rounded to the obscure, postero-inner angle. Crown presenting a broad, faintly-depressed slope, culminating in a low ridge closely bordering the postero-lateral side, to which it is abruptly sloped and merged into the distinctly-defined, narrow, marginal fold. Coronal punctation relatively coarse and closely arranged, very similar to that observed in the mandibular and maxillary posterior teeth.

The specific relations of the above described form are, of course, only inferentially determined. It might appear to be an anomalous state of things, especially in view of the fact that the mandibular and maxillary posterior forms of the species to which it is provisionally attributed occur in comparative numbers, the latter form should be represented by a unique example. But the small size of the teeth, and their thin, scale-like fragility, may in part, at least, account for their rare preservation and infrequency in collections.

Geological position and localities: St. Louis limestone; Alton and Monroe county, (Illinois); St. Louis, (Missouri), and Pella, (Iowa).

GENUS CHITONODUS, St. J. and W.

Teeth representing the various forms characteristic of the genera of *Cochliodonts.*

Mandibular posterior teeth trapezoidal in outline, strongly to moderately arched in the direction of inrollment. Antero-lateral border generally but slightly oblique to a line projected between the anterior and posterior angles of the inner margin, basal portion channeled, continued downward and outward into a thin marginal rim, bordered above by the narrow, inbeveled fold of coronal enamel; postero-lateral border converging toward outer side or point of inrollment at a moderate angle, basal portion expanded into a thin rim projecting a greater or less distance beyond the coronal border and terminating in the more or less produced spur of the posterior angle, in front similarly channeled and defined above by the rounded enamel fold as observed in the opposite border; inner margin most strongly arched backward in passing the base of the prominent median lobe of the crown, with deep, broad sinus or deflection in the region of the posterior alation, in general presenting a moderate sigmoidal curvature, inferior edge usually inbeveled, though originally, or when entire, continued downward in a nearly vertical basal wall; outline of the outer inrolled margin the reverse of that last described. Coronal region presenting a principal or median ridge culminating near the middle of the crown, the anterior slope moderate and uniform to the angulation or slight depression defining the very narrow belt skirting the antero-lateral border; the posterior slope more abruptly descends into the broad depression in that flank, whence arises the prominent posterior alation. Coronal surface further marked by subordinate revolving ridges and furrows variable in disposition and distinctness of definition, also ornamented by delicate transverse rugæ or reversed imbrications disposed in more or less parallel order conforming to some degree with the direction of the inner margin, though subject to interruption by implantation and bifurcation, also obsolete or variable in occurrence in species and individuals; otherwise the surface presents the punctate structure common to allied genera. Inferior surface, enveloped in the dense homogeneous layer, smooth or faintly striated longitudinally, repeating in a less marked degree the coronal contour.

Median teeth of mandibles relatively narrow, trapezoidal in outline, arched and strongly inrolled longitudinally; postero-lateral border conforming to the articular border of the posterior form and constituting the longer side of the tooth, antero-lateral border gradually converging toward the outer extremity, both borders showing the channeled basal portion bordered above by the narrow inbeveled enamel fold, inner margin obliquely rounded from the posterior to the anterior obtuse angle. Coronal surface occupied by a more or less prominent ridge situated nearest the postero-lateral border, on which side the declivity is abrupt, and defined by a narrow subordinate lobe immediately along the border, opposite side more gradually sloping towards the antero-lateral border, which is similarly margined by a narrow ridge with intervening shallow furrow. Surface ornamentation the same as noted in connection with the posterior terminal form.

Maxillary posterior teeth subquadrilateral in general outline, moderately arched and strongly inrolled along the outer margin. Antero-lateral border slightly oblique to the general course of the inner margin, basal portion channeled and produced downward and outward in a thin rim, defined above by the narrow inbeveled enamel fold; postero-lateral border converging toward point of inrollment somewhat more rapidly than in the case of the opposed mandibular teeth, with which it bears much the same characters in respect to the basal portion and enamel fold along the upper edge; inner margin most arched round the base of the posterior coronal lobe, in front of which it is more or less deflected inward and forward, thence gently arching round the anterior prominence to the obtuse anterior angle. Coronal region divided into two principal revolving elevations, of which the posterior one is much the most prominent, occupying about half the lateral diameter of the crown, the broader slope rising from the postero-lateral border and culminating nearer the anterior side, with a more abrupt slope descending to the median depression; the latter presents a broad transversely more or less concave area, the surface rising anteriorly into the more or less well-defined anterior prominence, thence the slope descends to the antero-lateral border. The coronal surface is further marked by more or less distinct, though generally obscure and sometimes obsolete subordinate revolving ridges and furrows which are chiefly noticeable in the region of the anterior prominence, though sometimes present in the median depression and the long slope of the posterior prominence; more or less distinct transverse rugæ disposed in the same manner noticed in connection with the mandibular posterior teeth, occur, producing an elegant imbricated ornamentation in the individuals thus distinguished. The latter superficial feature is, however, obsolete in some species, and which is equally applicable to all the other forms of certain species of undoubted congeneric relationship.

In regard to the character of the teeth occupying the extremities of the jaws, we can little more than conjecture their identity. Amongst the numerous examples of transversely elongate teeth which were originally disposed in serial order, and which are recognized under various generic appellations which in themselves constitute well-defined groups, there are possibly included forms which may have been associated with the teeth under present consideration.

The generic relations of the forms embraced under the above designation are most intimate with *Cochliodus*, Agass. Indeed they differ chiefly in the less well defined differentiation of the coronal regions, while in ***Cochliodus*** these parts are sharply limited, the species being chiefly distinguishable by differences in proportions. The absence of transverse rugæ may be deemed of greater than specific importance. The genus, however, presents in the ensemble of its specific forms and the within bounds somewhat diverse characteristics, features which indicate for it an important position at the head of this particular group of the family, and from which *Cochliodus* was probably an off-shoot at a later date. It embraces besides the Burlington forms, species occurring in the Keokuk formation described under the terms *Cochliodus latus*, Leidy, (*Cochliodus nobilis*, N. and W.) *Pœcilodus rugosus*, N. and W., (including *P. ornatus*, N. and W.), etc. We are not aware of the existence of later representatives than those above enumerated from the Keokuk formation and a single species from the St. Louis, the Chester species belonging to typical *Cochliodus*.

Were we in possession of sufficiently complete materials to conclusively demonstrate the relations of the species characterized by the presence of the transverse imbrications or rugæ, and those in which the coronal surface is simply marked by more or less subordinate revolving furrows and ridges, it might be found that these constitute two distinct groups more or less well defined one from the other. In that event *Cochliodus latus* would naturally fall into the group represented by the primitive Burlington species *Chitonodus antiquus;* while on the other hand, the Keokuk "*Pœcilodus rugosus*" would remain in association with the species here first described under *Chitonodus Springeri*.

CHITONODUS SPRINGERI, St. J. and W.

Pl. VI. Fig. 3-15.

Mandibular posterior teeth trapezoidal in outline, strongly inrolled. Antero-lateral border with a slightly oblique course outward and forward, of moderate height, coronal enamel forming a narrow band abruptly folded over the edge and inbeveled to the channeled, closely pitted basal portion; postero-lateral border converging towards point of inrollment at an angle of about 50° with the opposite side, coronal enamel forming a well-marked rounded fold along the upper edge of the channeled basal portion; inner margin making a right angle with the antero-lateral border, gradually produced backward from the obtuse anterior angle and sharply curved round the base of the coronal prominence, with a corresponding deep sinuation in passing the posterior depression into the subacute posterior extremity, usually inbeveled. Superficial characters pronounced and quite persistent in their uniformity. Median ridge rising into a rather sharply rounded crest nearly median in position, the anterior slope moderate and slightly concave transversely, terminating in a shallow depression bordered by a very narrow fold immediately along the antero-lateral border; posteriorly the surface abruptly descends into the depression on that side, whence the alate expansion gradually rises with slight transverse concavity into the moderately elevated postero-lateral border. The coronal surface is quite regularly marked by transverse rugæ parallel with the inner margin, the interspaces nearly a millimetre in breadth and rising from below upward producing a reversed imbricated appearance. The ornamental rugæ are most distinct over the depressed areas; in the more elevated exposed portions of the surface they are usually obsolete; however, there are traces of their presence over the entire area of the coronal region. The punctate structure presents the usual appearances associated with teeth whose coronal surface is traversed by transverse ridges and furrows, the punctæ being elongated usually in the direction of inrollment along the transverse folds; exfoliated and worn surfaces showing a relatively minute, crowded punctation. Transverse diameter at the inner margin of a medium-size tooth 20 mm.; length of antero-lateral border to point of inrollment 10.5 mm.

Mandibular median tooth of proportionate size in relation to the posterior form, trapezoidal in outline, elongated in the direction of inrollment. Postero-lateral border nearly straight, opposite border converging toward the outer extremity at an angle of about 20°, inner margin very oblique with a slight sigmoidal curvature from the sharply rounded posterior angle to the obtuse anterior angle. Coronal ridge situated posterior of the median line, of moderate prominence and breadth, posterior slope abrupt and deep to the narrow furrow close along the postero-lateral border, over which the coronal enamel forms a narrow inbeveled fold; anterior declivity nearly equally steep but of less depth, defined by a rounded angulation whence the surface more gently descends with slight transverse convexity to the antero-lateral border just within which lies a shallow parallel furrow recalling that adjacent the articular border of the terminal tooth. Along the posterior border and over a large part of the anterior slope the surface preserves the parallel, rarely bifurcating transverse rugæ, conforming to the direction of the inner margin, and spaced as previously noted in relation to the last described form, with which the general character of the surface punctation also agrees. The present form is represented by half a dozen or so imperfect specimens, which, while they are readily recognizable, are insufficient for comparative measurements showing their proportionate dimensions,—a mature example having a transverse diameter across the inner margin of 12.5 mm.

Maxillary posterior teeth corresponding in dimensions with the posterior form of the mandible, presenting the general outline ascribable to this form, moderately arched longitudinally and strongly inrolled along the outer margin. Antero-lateral border slightly oblique to a right line connecting the inner angles, presenting a channeled basal rim defined above by the narrow inbeveled fold of coronal enamel; postero-lateral border approaching point of inrollment at an angle of 60°, and less, to the opposite border; inner margin broadly arched round the base of the posterior lobe, in front of which it is sharply contracted and thence continued in a slightly concave course to the anterior prominence, round which it makes a broad curve terminating in the obtuse anterior angle. The definition of the anterior and posterior regions of the crown is marked; posterior lobe occupying apparently less than half the lateral diameter of the tooth, broad posterior slope gently and regularly arched transversely, in front steeply sloping from the sharply rounded crest to the angulation forming its anterior limit; the surface of the relatively wide depressed median belt gently rises into the summit of the anterior lobes, which latter usually presents a more or less well-defined, narrow, rounded ridge, sometimes two or more obscure ridges, in part occupying the moderately abrupt slope along the antero-lateral border; in some examples faint revolving ridges extend over the depressed median belt, and in others obscure impressed lines may be traced in the wide slope of the posterior lobe. In the perfect state the entire coronal surface was occupied by transverse rugæ parallel with the inner margin and more or less so to one another, though in the latter respect exhibiting considerable variation in the broken continuity, bifurcation, and implantation of the rugæ, which have the same appearance as in the preceding forms mentioned above. Toward the outer margin and indeed over the middle portion of the crown where its surface was subjected to greatest attrition while in use, the rugæ are obsolete or nearly so, though in some instances still traceable in the disposition in transverse lines of the more or less elongated or confluent punctæ, which are conspicuously displayed over the entire surface save along the inner margin where the external enamel layer is densest. A mature specimen measures in greatest breadth between the inner angles 30 mm. more or less, length along antero-lateral border 14 mm.

With the exception of the narrow median teeth, the forms whose specific identity is here recognized are represented in about equal numbers of individual teeth in the collections. The mandibular posterior form exhibits some variation, especially in certain examples which show faint revolving ridges or furrows over the broad anterior slope of the coronal prominence, as illustrated in one of the figures representing a tooth referred to this species. The latter feature also recurs in some of the Streblodoid teeth of the upper jaw, as already noticed, and although the absence of these obscure furrows and ridges does not in all cases appear to be attributable to the accidents of wear, their presence in certain individuals is not associated with other characters which might be deemed sufficient grounds for their separation from the specific relations here recognized. Amongst the latter there occurs a single individual from Buffington creek, which, in the relative proportions of the coronal regions with which are associated other features, offer in the main rather marked contrasts with the superficial characteristics noticeable in the typical examples of the form described above. These consist in the relatively wide posterior lobe, the less distinct angular culmination of its crest and gentler anterior declivity, proportionately narrower median depression, more regularly transversely arched anterior lobe, and the upward and forward deflection of the imbrications or transverse rugæ in crossing the median depression, constituting striking features in contradistinction of those recognized in consequence of their prevalence as normal in the typical representatives. Illustrations of the latter specimen are also introduced, although its identity with the present species is only provisionally inferred. Also amongst the few representatives of the mandibular median form the normal condition described above is departed from in appreciable degree, presenting a form distinguished by a relatively elevated regularly arched coronal prominence and correspondingly depressed anterior slope, in which the oblique transverse rugæ are more interrupted in continuity than occurs in the case of the typical individuals. The somewhat pronounced variations noted may indeed constitute permanent characteristics such as a larger suite of specimens might prove to possess specific value. But at the present time, owing chiefly to the imperfect state of preservation of the material in which many important details are masked, the evidence is not deemed sufficient to justify the separation of these individuals from the more characteristic representatives of the species with which they are associated.

Compared with heretofore described species, the present one is allied to that occurring in the Keokuk formation described by Messrs. Newberry and Worthen, under the names *Pœcilodus rugosus* and *P. ornatus*. [1]The species differ, however, in several marked peculiarities. The closest resemblance between them is noted in connection with the proportions and coronal contour of the mandibular posterior teeth, the Upper Burlington form being mainly distinguishable by the more delicate and close arrangement of the transverse imbrications. The median teeth of the mandibles of the two species differ to a greater extent one from the other, the coronal prominence in the present species possessing greater elevation and more pronounced differentiation of the culminating ridge. In the posterior teeth of the upper jaw the divergence in the contrasts between the species is even more emphasized, the Upper Burlington examples being destitute of the supplementary rugosities that surmount the crest of the posterior lobe in the Keokuk species.

It seems not, therefore, improbable that the examination of a larger suite of specimens may reveal the existence of a contemporaneous species during the Upper Burlington epoch, which the present material rather suggests than demonstrates, much less affords the necessary data for the satisfactory discrimination of its distinctive characteristics. The illustrations convey a fair impression of the species as determined from such remains as are at hand, while at the same time they serve to show the variable appearance individual specimens present, the limits of which are difficult to define.

Geological position and localities: Upper Burlington limestone: Burlington, Buffington creek, Louisa county, Pleasant Grove, Augusta, Iowa; Quincy, Ill.

CHITONODUS ANTIQUUS, St. J. and W.

Pl. VI, Fig. 2.

Mandibular posterior tooth less than medium size, trapezoidal in general outline, strongly inrolled and correspondingly arched longitudinally. Antero-lateral border making nearly a right angle with

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NOTE.—[1]Illinois Geol. Surv., II, pp. 94, 95, Pl. VIII, ff. 13, 14.

a line connecting the angles of the inner margin, or very slightly oblique in its forward and outward course, the coronal enamel forming a shallow fold inbeveled to the channeled basal portion; postero-lateral border not shown; inner margin produced obliquely backward and rather sharply rounded at the base of the coronal ridge, thence making a concave curvature to the acute posterior extremity. Coronal ridge nearly median, culminating in a rounded crest, posterior slope abrupt to the depression on that side, whence steeply rises the posterior alation, also steeply sloped in front and defined by a faint angulation from the relatively plain belt occupying the anterior portion of the crown, and which is apparently destitute of longitudinal furrows or transverse rugæ. Coronal surface regularly and closely punctate. Transverse diameter across the inner margin 15.5 mm.; length along antero-lateral border 9.5 mm.

The above description is based upon a single imperfect specimen derived from the Lower Burlington limestone, and which is the earliest discovered representative of the genus. The somewhat distinct demarkation of the plain anterior area of the crown offers a character recalling typical *Cochliodus*, its relative great breadth constituting the chief distinguishing feature; on the other hand, the coronal contour is remarkably similar to that ascribed to *Chitonodus*, of which we believe it to be a worn example. Its relations to the species so well represented in the collections from the next succeeding or Upper Burlington deposits cannot be fully determined; but the before-mentioned marked definition of the coronal ridge from the plain belt in front presents a striking contrast in contour with the same form of *C. Springeri*. Not even worn examples of the latter species, in which the transverse and even the longitudinal folds are obliterated, bear any intimate resemblance in the particulars alluded to as characteristic of the present tooth.

Geological position and locality: Lower Burlington limestone; Burlington, Iowa.

CHITONODUS TRIBULIS, St. J. and W.

Pl. VII, Fig. 18-21.

Teeth of medium size, of which representatives of the mandibular and maxillary posterior forms alone are known.

Posterior teeth of the maxillaries presenting the usual sub-quadrilateral outline, strongly arched and inrolled along the outer margin. Antero-lateral border forming nearly a right angle, with a direct line uniting the inner, anterior and posterior angles, basal portion channeled, coronal enamel forming a narrow inbeveled fold along the upper edge; postero-lateral border very oblique, forming an angle of 40° to 50° with the opposite border, in respect to basal portion and shallow enamel fold, presenting the usual generic characteristics; inner margin strongly arched from the subacute posterior extremity round the base of the posterior lobe, in front of which it forms a rather deep broad sinus, and again broadly arched in passing the anterior coronal prominence to the obtuse anterior angle. Coronal region nearly centrally divided by the median depression; posterior lobe prominent, anterior face steeply rising into the rounded crest, whence the broader slope more gradually and regularly descends with slight transverse convexity to the postero-lateral border, just above which lies a faint depressed parallel belt; median depression occupying less than one-fourth the lateral area of the surface, rather deeply excavated and usually well defined; crest of anterior lobe near the posterior side, the broad slope descending in regular convexity to the antero-lateral border. Surface marked by transverse rugæ or imbrications over the less abraded portion of the posterior lobe, and which on reaching the median depression are, in some instances, rather strongly deflected from a direct course downwards and forward, becoming obsolete in the region of the anterior lobe, which is occupied by irregular prominences, producing an elegant verrucose ornamentation, irregular ridges sometimes taking the place of the verrucose prominences; surface punctæ fine, spaced by little more than their own diameter. A mature specimen measures in greatest diameter between the inner angles 40 mm.; length of antero-lateral border to point of inrollment about 15 mm.

Mandibular posterior teeth sub-trapezoidal in outline, strongly arched and inrolled. Antero-lateral border moderately oblique in its outward and forward course from the very obtuse inner angle, channeled and limited above by the narrow enameled fold; postero-lateral border converging toward point of inrollment at an angle of 50°, or less, with the inner margin presenting the usual channeled condition and enamel fold above; inner margin strongly arched round the base of the median ridge, with a broad concave curvature behind in passing into the produced subacute posterior extremity. Median lobe of crown culminating in a sharply rounded crest, anterior of a line through the centre of the tooth, steeply sloping and merging into the moderately depressed anterior belt, the opposite side abruptly descending into the deep posterior depression, alate lobe somewhat steeply upraised and relatively wide, transversely convex and thickened along the border. The superficial transverse rugæ show strongest development in the anterior slope and the posterior wing, in the latter region being nearly at right angles to their course in the former space, where, in some examples, at least, the surface is marked by stronger rugosities descending from the crest of the median ridge. Surface punctæ the same as described in the opposed maxillary teeth. A specimen below medium size measures across the inner margin 15 mm.; length along antero-lateral border to point of inrollment 9 mm.

Only the posterior teeth of the upper and lower jaws of the present species have been identified, represented by half a dozen individuals of each form, and these, with one or two exceptions, in the usual fragmentary state of preservation. Compared with the forms of the species with which they are associated, *C. rugosus*, (N. and W. sp.), the maxillary teeth are distinguishable by the relative greater prominence of the posterior lobe, the verrucose ornamentation of the anterior lobe, and, perhaps, the course of the transverse rugæ in the region of the median depression. The mandibular teeth also differ in the relative prominence, the sharply rounded crest of the median lobe, depth of posterior depression, proportionately greater breadth of the alate lobe, and more robust build. In some of the features contrasting with the associate species there are more intimate resemblances with the Upper Burlington species, *C Springeri*, especially as regards the mandibular posterior teeth; but the maxillary teeth of the latter, again, are more like those of *C. rugosus*, though they are not to be confounded with that species.

Geological position and localities: Keokuk limestone, main fish-bed horizon; Keokuk, Bentonsport (Iowa), Hamilton, Warsaw, Nauvoo and Scott county (Illinois).

CHITONODUS LIRATUS, St. J. and W.

Pl. VI, Fig. 1.

The present species is represented by a solitary imperfect example of a maxillary posterior tooth, showing the anterior portion, the posterior lobe having been destroyed. The part preserved, however, indicates a tooth of small size, with a diameter across the inner margin probably not exceeding 13 mm., with a length along the antero-lateral border to point of inrollment a trifle less than 5 mm., in outline showing the usual quadrilateral figure. The antero-lateral border is very oblique in its course forward and backward, coronal enamel forming a strong, rounded fold inbeveled to the channeled basal portion; inner margin gently arched round the base of the anterior coronal prominence with a slight concavity forward, and a broader one in the region of the median depression; postero-lateral border unknown. Anterior portion of the crown occupied by a pair of low, regularly transversely arched ridges, separated by a shallow, well-defined furrow, and posteriorly defined by a broader median depression intervening between the anterior and posterior lobes. Surface more or less regularly marked by strong, closely arranged transverse imbrications parallel with the inner margin, and apparently extending over the entire coronal region, besides showing a relatively coarse, crowded punctate structure.

The species indicated by the fragment of tooth above described apparently constitutes a typical representative of the genus *Chitonodus*, of which it is the latest that has, as yet, been made known. It exhibits intimate relations with the Keokuk *C. rugosus*, but is distinguished by its small size, the greater outward and backward obliquity of the antero-lateral border, and the double-lobed broad anterior prominence; the transverse imbricated ornamentation markedly partakes of the generic characteristics associated with species of the genus.

Geological position and locality: St. Louis limestone; Alton, Illinois.

GENUS COCHLIODUS, Agassiz.

COCHLIODUS VAN HORNII, St. J. and W.

Pl. VII, 1-10.

Teeth below medium size, representatives of the mandibular posterior and median, and maxillary posterior forms are known.

Mandibular posterior teeth in the outline and contour of the triturating surface presenting in a remarkable degree the typical characteristics of the genus, strongly inrolled at the outer margin. Antero-lateral border with a slightly curved outline, the enamel fold occupying about one-third of the vertical space and sharply defined by a narrow channel from the downward and outward projecting basal portion, which terminates in a thin rim inferiorly, the axes of the channel showing relatively coarse pits; postero-lateral border with a moderate sigmoidal curvature, diverging posteriorly at an angle of 50° with the opposite border terminated in the acutely rounded posterior angle, coronal fold equally sharply defined from the basal portion, which is more or less expanded toward the posterior extremity where it forms a wide platform extending beyond the limits of the coronal border, the channel similarly marked by a row of large vascular pits; general direction of inner margin nearly at right angles to the antero-lateral border, broadly arched round the base of the median prominence, and again gently curved sigmoidally in passing to the posterior extremity; coronal region defined by an abruptly inbeveled narrow fold from the deep basal area which terminates inferiorly in a very thin edge; surface irregularly and coarsely marked by vertical rugosities and sulci;—usually, however, the attenuated rim is broken away, and the margin abruptly inbeveled. Coronal contour strongly arched in the direction of inrollment; anterior belt well defined from the median prominence, slightly, sometimes strongly, arched transversely, with a slight furrow along the anterior edge in well preserved examples; median prominence occupying half the lateral diameter of the crown, strongly and regularly arched transversely, the rounded axis lying a little anterior of the middle, the broader slope descending into the posterior depression where it is defined by a marked angulation; posterior alation proportionately wider than the anterior plane belt, faintly depressed in the middle and slightly arched transversely along the moderately upraised postero-lateral border, where the edge of the coronal enamel is inbeveled similarly to the enamel fold along the antero-lateral border, and rounded at the extremity. Along the inner margin of the well preserved tooth the surface is invested in a dense semi-opaque enamel through which the extremities of the tubular structure are faintly outlined; in worn surfaces, this same structure produces a minute, rather widely spaced punctuation, of which there are about 30 pores in the space of a square millimetre. Greatest transverse diameter of the crown of a medium-size example across the inner margin 15 mm., or to the extremity of the basal spur 17 mm.; length of antero-lateral border to point of inrollment 10 mm.; greatest depth ditto, 1.5 mm.; length along postero-lateral border to the inrolled outer margin 10 mm.

Mandibular median teeth sub-triangular in outline. Postero-lateral border slightly curved sigmoidally in conformity with the anterior articular border of the posterior terminal tooth, basal portion rather deeply channeled and coarsely pitted, forming the greater part of the height of the border, well-defined from the enamel-fold and terminating below in a thin outward produced rim; antero-lateral border converging toward outer extremity at an angle of about 30° with the opposite border, relatively short, similarly channeled and pitted as mentioned in connection with the posterior border; inner margin making a marked sigmoidal curvature, broadly rounded in passing the base of the coronal prominence, and thence curved outward on approaching the obtuse anterior angle, joining the posterior border nearly at a right angle. Coronal contour presenting a simple median ridge, the posterior slope slightly arched transversely and gently descending to the postero-lateral border, which is occupied by an abruptly beveled slightly depressed belt margined by a narrow, minutely crenulated fold distinctly defining the coronal and basal portions,—worn individuals showing a more or less rounded edge; the opposite slope declines more abruptly into a shallow depressed belt occupying the anterior surface, bordered by the narrow alation, over the edge of which the enamel makes a regularly rounded fold sharply defined along the strongly inbeveled margin from the basal portion; along the inner margin the coronal region is defined by a narrow rounded fold inbeveled to the deep basal belt, which extends downward into a thin edge corresponding with that of the posterior tooth. Superficial enamel and punctate structure the same as described in connection with the preceding form. Length along postero-lateral border 10 mm,; greatest breadth between the inner angles 9 mm.; length of antero-lateral border to point of inrollment 6 mm.

Ultimate teeth occupying the dentigerous extremity of the lower jaw unknown.

Maxillary posterior teeth (*Streblodus*, Agass.) subspatulate in general outline, strongly and regularly arched from within outward. Antero-lateral border with slight forward obliquity to the long axis of the tooth and gently curved sigmoidally, basal portion channeled and extending downward and outward into a thin rim, coarsely pitted; postero-lateral border broadly arched in a slight sigmoidal curvature, converging toward inrolled outer margin at the angle of 55° to 65° with the opposite side, basal portion apparently relatively low, channeled, and posteriorly expanding beyond the coronal limit terminating in the more or less produced, acutely rounded posterior extremity; inner margin making two broad arches, the larger in rounding the base of the postero-coronal prominence, the lesser in skirting the anterior prominence on the way to the obtuse anterior angle, in ordinarily preserved teeth inbeveled inferiorly. Coronal contour typical of the corresponding form of the genus, divided into two principal regions occupied respectively by the posterior lobe and the narrower anterior prominence. The posterior prominence culminates about one-fourth the distance from the shallow sulcus forming the demarkation between the coronal elevations, the anterior acclivity rising quite steeply into the obtusely rounded crest, whence the surface much more gently declines in a slight concavity to the postero-lateral border, where the enamel forms a narrow fold distinctly defined from the basal portions; anterior lobe more regularly and gently arched transversely, the longitudinal axis lying near the median depression with a narrow steep slope on that side, the wide, gentle anterior slope being interrupted by more or less distinct revolving furrows, margined along the antero-lateral border by a narrow plane belt defined from the anterior prominence by a slight impressed line, the coronal enamel forming a very narrow fold along the antero-lateral border. Greatest breadth of medium-size tooth across inner margin 21 mm.; length of antero-lateral border to inrolled outer margin 8 mm.; greatest length along crest of posterior lobe 13 mm.; position of median depression a little anterior of a line drawn through the centre of the tooth. A large size specimen in the collection of Mr. Van Horne, from Alton, is quite one-third larger than that indicated in the above measurements.

Although the collections afford no positive evidence of the specific identity of the dental elements belonging to the anterior extremity of the upper jaw of the present species, there is, however, a well represented form of teeth occurring in series precisely after the Helodus-like teeth associated with the magnificent group of teeth furnishing the basis for the description of the species *Chitonodus latus*, (Leidy sp.) (*Cochliodus nobilis*, N. and W.). More frequently occurring as isolated teeth, examples of two or more teeth occupying their natural relative position in deltoid series have been obtained, so that little doubt can be entertained as to their relations with some Cochliodont, probably to the species herein mentioned. Teeth occurring in series of two or more individuals, together forming a deltoid figure, narrowing from within outward, and presenting a triturating surface interrupted by prominent transverse ridges and intervening deep furrows, corresponding to the coronal crests of the individuals of the series; in some instances the individual teeth are so intimately united along the impingement of their bases as to obliterate all trace of suture; again, in other examples the original or occasional individuality of the teeth is indicated by a faint suture, extending in from the borders of the series, while others again show the complete series in natural successional order, but with their bases free. The individuals of the series regularly diminish in size from within outward, although the tooth of the inner margin sometimes presents an immature coronal crest, adhering to the inner basal declivity of the immediately preceding fully developed tooth, a feature known to obtain in the *Helodus*-like teeth associated with *Chitonodus latus*, e. g. *Helodus consolidatus*, N. and W. The independent teeth are distinguished by their long-elliptical transverse outline seen from above, slightly arched backward along the inner margin of the crown, the opposite side being protuberant in the middle, with concave curvature towards the extremities. The crown rises into a tumid eccentric apex nearer the postero-lateral (?) extremity, outer face slightly concave, opposite side moderately convex, sharply inbeveled and defined from the base, the extremities marked by a sort of enamel fold, which also faintly appears along the outer margin, but destitute of imbrications, such as appear in the coronal belt of *Chomatodus*. The base is relatively shallow, inbeveled in front, more or less channeled and irregularly coarsely pitted, inner margin much produced outward and downward to the dull inferior edge, vertically coarsely rugose; inferior surface faintly depressed, smooth. The large tooth of a medium-size series of three firmly coälescent individuals measures in lateral diameter of crown 6 mm., diameter at the middle 2 mm.; greatest height of crown 1 mm. Crown originally enveloped in a dense semi-opaque enamel, the worn surface showing rather widely spaced punctæ, varying, however, considerably in the latter respect. The associated teeth clearly homologous with the present form, present rather a wide range in variation, particularly in respect to the contour of the coronal region. In some of the teeth the crown is much depressed; in others, again, the outer face presents a wide, plain, elliptic area, the inner slope very low, and the crest crowded over past the basal border, in which condition it resembles certain forms of *Tanaodus*, although the base is entirely different from that of the latter genus.

The foregoing diagnosis of the characteristics pertaining to each of the several dental elements here recognized as having formed part of the dentition of this interesting species, presents in sufficient detail the peculiarities which distinguish it in comparison with other species of the genus. It remains briefly to observe the association of certain teeth in their original relative position upon the jaws, examples of which, fortunately, have been obtained by Mr. Van Horne and Prof. Worthen. The most complete specimen of the mandible shows the posterior and median teeth planted upon a thin semi-osseous tissue composed of coarse granules of ossific matter, the walls of which are strengthened from within by a system of transverse bars, like girders, which serve to maintain the shape of the surface upon which the crushing plates rest. The teeth are separated from the supporting rami by a film of calcite, which probably represents the bulk of the tegumentary or formative tissue that enveloped the dentigerous portions of the jaw. The mandible extends anteriorly into a slightly produced, bluntly rounded extremity, which from the inferior surface shows on either side of the symphysial line a shallow pit, which may indicate the position of the corresponding concavity of the dental plate or tooth occupying the extremity of the jaw; but not a vestige of the latter exist in the specimen, and therefore in regard to their form we are as much in the dark as heretofore. Although the maxillary anterior teeth have been provisionally identified, we are unable to conjecture even the form of the opposed mandibular teeth—whether they presented a series of distinct coronal crests or merely a simple inrolled plate. A remarkable specimen of the mandible, belonging to the Woodwardian Museum, obtained from the mountain limestone of Bristol, England, and which was described by Professor Owen, (Geol. Mag. 1867, IV, p. 59, Pl. III, f. 1, 2,) shows the extremity of the rami of *Cochliodus contortus*, Agass., occupied by a third tooth, the smallest of the series, and presenting a triangular shaped, inrolled plate, traversed by a prominent median ridge which is described as being "very convex and obliquely and gently contorted from behind and below, upward, inward and forward, with a slight increase of breadth or fore and aft diameter. * * * The anterior lobe seems to have had the form of a small tubercle, but its summit is broken off; the posterior lobe is a narrow, seam-like, raised border, extending further back on the outer side, **fig. 2 a,** than on the inner side of the ramus." Our specimens, unfortunately, afford no means of confirming the observations based on the Bristol specimen, nor do the collections afford examples of teeth corresponding to the anterior form described by Professor Owen.

In relative frequency of occurrence it would, of course, be expected that the larger and more massive teeth appear most abundant in the collections. The posterior teeth of the mandibles and maxillaries are represented about equally in numbers, while the narrow median teeth of the lower jaw, and the *Helodus*-like forms presumably pertaining to the anterior portion of the upper jaw, are less frequently met with. This is also true of other species of the same and allied genera occurring in the Lower Carboniferous formations, and the absence of certain forms ought not to militate against the conviction of their existence.

Geological position and localities: St. Louis limestone; Alton, and Monroe county, Illinois; St. Louis, Missouri; Pella, Iowa.

COCHLIODUS OBLIQUUS, St. J. and W.

Pl. VII. Fig. 17.

Tooth resembling in coronal contour the form assigned to the posterior position on the upper jaw, very small, obliquely trapezoidal in outline, moderately arched in the direction of inrollment. Antero-lateral border nearly straight, obliquely produced forward from the inner angle, making an angle of about 40° with a right line connecting the anterior and posterior angles of the inner margin, low basal portion forming a shallow, channeled rim, defined above by the narrow, rounded, inbeveled enamel fold; postero-lateral or oblique border converging from the rounded posterior extremity to point of inrollment, at an angle of 20°, more or less, with the opposite border, basal portion relatively deep, moderately inbeveled and slightly channeled, the coronal enamel forming a delicate fold defining the upper edge; inner margin broadly arched round the base of the postero-coronal lobe, thence to the obtuse anterior angle nearly straight and closely conforming to a line connecting the inner angles of the tooth. Coronal region presenting a strong posterior prominence, the broad outer slope rounding into the border, from which it is defined by a slight depressed belt, anterior slope more abrupt and making a slight angulation where it joins the anterior depressed portion of the crown; the latter presents an area of about the same breadth as that occupied by the posterior lobe, depressed, and marked by two faint, revolving folds, with a third stronger ridge along antero-lateral border to which its anterior slope is steeply beveled. Enamel coating along inner margin showing faint lines of growth, the worn crown surface exhibiting relatively coarse crowded punctæ. Length of antero-lateral border to point of inrollment 1.5 mm.; breadth across inner margin, 2.5 mm.

The above form is represented by a single example, and notwithstanding its minute size, the perfect state of preservation of the tooth permits a detailed interpretation of its diagnostic characteristics and comparison with allied forms. We are, however, in some doubt as to its generic identity, although there is strong evidence of its intimate relationship with *Cochliodus*, the Strebloidal maxillary posterior form of which it closely resembles in coronal contour. This unique specimen, however, does not seem to be referable to the associated species *Coch. Van Hornii*, unless we are to suppose a most extraordinary change takes place, by which young and mature teeth are made to assume the most unlike semblance to one another. The present tooth, however, compared with the streblodoid maxillary form of *Coch. Van Hornii*, is distinguished by the following pronounced contrasts: the general obliquity of outline and relatively narrower breadth compared with the length in the direction of inrollment (a feature which is necessarily persistent and directly dependent on the law of development of the dental plates), the extremely prominent posterior lobe, and the depressed median portion of the neck defined by the comparatively prominent ridge along the antero-lateral border. It is in the latter respects the form here especially alluded to offers greatest contrast with the prevailing coronal contour of *Cochliodus*, and suggests a possible relationship with *Deltoptychius*.

Geological position and locality: St. Louis limestone; St. Louis, Missouri.

COCHLIODUS LEIDYI, St. J. and W.

Pl. VII. Fig. 11-16.

Teeth of small size, the collections furnishing representatives of the posterior and median teeth of the mandible, and the posterior form and Helodus-like series of teeth of the upper jaw.

Mandibular posterior teeth distinguished by their compact build and relatively narrow transverse diameter compared with the length in the direction of the strong enrollment. Antero-lateral border slightly curved between the inner angle and point of inrollment, presenting the usual channeled and downward and outward projecting basal rim which is coarsely pitted, the border having a course slightly oblique outward and forward to the transverse axis of the tooth; postero-lateral border converging toward the outer margin at an angle of about 60, basal portion channeled and somewhat produced beyond the coronal limits towards the posterior extremity; inner margin broadly arched round the base of the principal coronal ridge, with a short concavity in front and a broader one in passing the posterior depression into the alate, subacute angle, worn specimens showing the usual inbeveled edge. Anterior belt of crown well-defined, narrow, slightly convex transversely, the coronal enamel folding over the antero-lateral border in a narrow inbeveled belt distinctly defined from the basal portion; median ridge prominent, relatively broad, occupying considerably more than half the transverse diameter of the crown, moderately and regularly arched transversely and well-defined on either side by an obtuse angulation or furrow separating it from the anterior belt and the posterior depression; posterior alation relatively narrow, considerably upraised, nearly plane transversely, the coronal enamel forming a delicate inbeveled fold along the outer edge. Surface minutely punctate, the medullary tubes somewhat widely spaced and about thirty occurring within a square millimetre, and disposed in scroll-like curves over the surface of the tooth. Length of a medium-size tooth along the antero-lateral border 8 mm; breadth between angles of inner margin 13 mm; breadth of median lobe at inner margin 8 mm; do. of posterior alation 3 mm; do. anterior belt 2 mm.

Mandibular median form, of which the collections offer a solitary imperfect example showing about half the inner portion of a mature tooth, exhibits a moderately elevated, sub-angular median ridge, a narrow concavity bordering the postero-lateral edge over which the enamel forms a narrow inbeveled fold distinctly defined from the channeled basal portion; slope in front slightly concave transversely on nearing the antero-lateral border, which latter, as also the very oblique inner margin, is mutilated and not clearly defined. Surface punctation similar to that observed in the posterior terminal form.

Maxillary posterior teeth subspatulate in general outline, strongly inrolled. Antero-lateral border slightly oblique with a gentle concave curvature outward and forward from the obtuse inner angle; postero-lateral border diverging at an angle of 25°, more or less, with the opposite border, presenting a broad gentle curvature between the point of inrollment and the sharply rounded posterior extremity, the basal portion extending considerably beyond the limits of the crown forming a thin marginal rim posteriorly; inner margin broadly arched in general course, suddenly constricted in front of the posterior lobe, and thence more gently arched to the anterior angle. Coronal region presents strong contour contrasts, posterior lobe prominent, constituting somewhat more than half the lateral diameter of the tooth, abruptly rising in front into the rounded crest from which the slope in the opposite direction gently descends in slight transverse convexity to the postero-lateral border, where the coronal enamel forms a thick inbeveled fold distinctly defined from the basal portion; the anterior neck is separated from the posterior prominence by a deep narrow depression, in well-preserved examples showing a distinct narrow secondary ridge with steep declivity bordering the median depression, a transversely more gently convex wider belt intervening between the latter and the shallow furrow defining the posterior limits of the narrow relatively prominent belt along the antero-lateral border, where the coronal enamel forms a well-marked fold inbeveled to the basal portion. Superficial punctation the same as in the opposed mandibular teeth. A mature tooth measures in greatest diameter of crown at the inner margin, 22.5 mm., the basal portion being considerably farther prolonged into the posterior spur; length of antero-lateral border to point of inrollment, 8 mm.; median furrow at inner margin, 13 mm. distant from posterior extremity.

Associated with the above described forms, the collections contain a few examples of *Helodus*-like teeth, mostly isolated individuals, but occasionally in series, which we are inclined to identify with the present species. One of these series, in the collection of Professor Worthen, presents a series of four teeth firmly soldered at the impingement of their bases, without visible suture, forming a deltoid figure, belonging to the right ramus of the upper jaw. The three outer teeth regularly and gradually diminish in size from behind outward, except the innermost one, which presents the usual condition of immature coronal ridge apparently resting upon the inner deep basal border of the immediately preceding tooth. The anterior basal margin of the outer tooth is channeled, the coronal ridge of all the individual teeth rises into a turgid sub-median apex nearest the postero-lateral border of the series, slightly concave along the sloping obtuse crest on either side and sharply deflected forward at the extremities into a sort of short fold; the inner margin is gently arched backward, the whole tooth moderately arched vertically and the crown-face vertically convex; the outer face slightly concave vertically, swollen in front of the summit, round which the basal line arches from its slightly concave course near the lateral extremities, which latter are somewhat angularly rounded. The inner and outer coronal margins are sharply inbeveled to the coarsely-pitted basal plate, which behind forms a wide area nearly in the plane of the inner crown-face. The surface punctation is fine, rather widely spaced, much after the same style described in the other forms of the species. The mature inner tooth of the series measures in lateral diameter, 8 mm.; greatest width from behind outward, 3 mm.; height of inner crown-face, 2.5 mm. The outer or fourth tooth of the same series is 6 mm. in lateral extent, the other dimensions proportionately diminished.

The above described forms embraced under one and the same specific designation, are well represented in the collections accessible to us from the Chester formation. The species is intimately allied to that described from the subjacent St. Louis limestone, *Cochliodus Van Hornii*, of which it constitutes a fine example of a representative species. As distinguished from the St. Louis species, the mandibular terminal tooth is relatively narrower in lateral diameter, stronger and more compactly built, the alation proportionately narrower and the median-lobe correspondingly wider; the narrow median tooth is apparently more elevated along the crest; the maxillary posterior teeth, on the other hand, are proportionately more elongate transversely, posterior lobe more prominent, and the median depression more deeply excavated and defined by steeper walls; in regard to the distinctions observable in the serial teeth, those supposed to pertain to the present species are perceptibly less elongate laterally, with less abrupt inner coronal face, and generally more robust proportions, as compared with the normally developed individuals of *C. Van Hornii*, which, as has been pointed out, vary to a very remarkable degree in their coronal aspects.

Geological position and localities: Chester limestone; Chester and Evansville, (Randolph county,) Prairie du Long, (Monroe county,) Illinois.

GENUS PŒCILODUS, Agassiz.

PŒCILODUS VARSOVIENSIS, St. J. and W.

Pl. VIII. Fig. 13, 14.

Posterior teeth of the upper jaw of small size, subelliptical in outline, strongly arched in the direction of inrollment. Antero-lateral border slightly oblique to the inner margin forward and outward; postero—lateral border gently arched and converging toward inrolled outer margin at an angle of 30°, more or less, with the antero-lateral border; inner margin moderately concave in the median region, broadly arched round the posterior lobe to the acutely rounded extremity, and similarly arched round the base of the less prominent anterior lobe to the obtuse anterior angle. Coronal region presenting a very oblique, moderately elevated, regularly transversely arched posterior lobe, a slight sulcus extending along the outer side parallel with the postero-lateral border, anteriorly defined by the moderately excavated median depression; the mutilated condition of the neck does not permit the contour of the anterior lobe to be satisfactorily made out, although it seems to have been moderately arched transversely. The posterior lobe shows a few relatively strong transverse corrugations, which are obsolete in worn examples; surface punctation fine and moderately spaced· Transverse diameter of a mature tooth at the inner margin 12.5 mm.; length of antero-lateral border 4 mm.

The above species is represented, in the collection of Mr. Van Horne by only two examples of the maxillary terminal form. The specimens are mutilated in the anterior region, but the posterior prominence exhibits the characteristic contour prevalent in certain species of the genus, hence its present reference. The transverse undulations of the posterior lobe recall the Chester species, *P. Cestriensis*, although they are less in number and not so deeply impressed in the interspaces; while the antero-lateral border seems to be longer and less obliquely curved outward and forward. Its relations with *P. St. Ludovici* are much less intimate, the presence of the transverse corrugations of the posterior lobe offering a marked distinguishing feature in contrast with that species. Should the anterior lobe be found, from the examination of perfect individuals to present a regularly convex elevation, instead of an angularly arched ridge, such as is characteristic of the genus *Pœcilodus*, the species represented by the present form would then have to be relegated to *Chitonodus*.

Geological position and locality: Warsaw limestone; near the mouth of Piasa creek, above Alton, Ill.

PŒCILODUS ST. LUDOVICI. St. J. and W.

Pl. VIII, Fig. 8-12.

Teeth of small size, representing the posterior forms of the upper and lower jaws; dental armament of the anterior portions of the jaws unknown.

Mandibular posterior teeth strongly arched in the direction of inrollment, in outline presenting the usual subspatulate form. Antero-lateral border relatively very short, forming nearly a right angle with a line connecting the angles of the inner margin, extremely attenuated and contracted from the anterior coronal ridge; postero-lateral border converging toward point of inrollment at an angle of 50°, more or less, with the opposite border, basal portion deeply channeled and widely expanded beyond the coronal limits posteriorly, terminating in the acutely rounded spur of the posterior extremity; inner margin making a deep regular concavity in the region of the posterior depression, broadly arched round the base of the median lobe, with a shallow concavity in the intermediate depression in front, and angularly arched round the anterior ridge, beyond which the course is suddenly and very obliquely deflected forward to the obtuse anterior angle. The coronal region is strongly marked by the characteristic contour features. Anterior lobe narrow, prominent, culminating in a rounded crest moderately oblique to the antero-lateral border, in front of the abrupt slightly convex slope, descending to the coronal limits, where it is bordered by a narrow slightly depressed belt, beyond which the basal portion projects as a wide, rapidly narrowing apron to the anterior extremity of the tooth; posterior slope equally abrupt but of less vertical extent; intermediate depression equaling the breadth of the anterior lobe, in perfect teeth showing a nearly plane area narrowing from within outward, defined from the bordering elevations by a slight angulation on either side, in worn and mature examples the depression presents a more or less deep, regular transverse concavity; median or principal lobe situate a little posterior of the median line, broadly and regularly arched transversely, the abrupt and longer slope descending into the posterior depression which is traversed by a slight angulation, whence the surface rises with slight concavity into the moderately upraised alation, along the border of which the thickened enamel is rounded over in a relatively wide inbeveled fold to the basal portion. The inner edge of the crown, in some specimens, shows a widish belt of the dense enamel without blemish, as it was when enveloped in the formative membrane; where the surface is exfoliated and abraded the coarse punctate structure is revealed. The surface is ordinarily marked by fine closely arranged punctæ, sometimes showing a disposition toward transverse arrangement, but otherwise smooth and destitute of corrugations. Greatest transverse diameter of a mature tooth across inner margin 16 mm.; length along crest of the anterior lobe to the outer inrolled margin 7 mm.; or about as great again as the length of the extreme antero-lateral border.

Maxillary posterior teeth subelliptical in outline, strongly inrolled along the outer margin. Antero-lateral border with a slightly oblique forward course, basal portion channeled and defined above by a relatively strong, inbeveled coronal fold; postero-lateral border converging toward point of inrollment at an angle of 30° to 40° with the opposite side, making a gentle regular curve from the produced, acutely-rounded posterior extremity to the inrolled outer margin, basal portion rather deeply channeled and expanded beyond the coronal border; inner margin broadly arched round the base of the posterior prominence, with a broad concavity in the region of the median depression, somewhat angularly arched round the anterior lobe to the obtuse anterior angle. Contour of the coronal regions strongly marked, posterior lobe occupying nearly half the lateral diameter of the crown, presenting a broad gentle slope posteriorly, slightly convex above and faintly depressed on nearing the border, which is defined by a rather strong inbeveled enamel fold; the anterior declivity abruptly descends from the more or less angularly rounded crest with slight concavity, merging into the deep, wide median depression; anterior lobe culminating in a sharply rounded crest flanked by nearly equally steep slopes on either side, that in front terminating in a narrow revolving groove or angulation which is bordered by the narrow, rounded marginal fold of the anterior border. Surface appearances the same as noted in the mandibular teeth above described, with the same tendency to transverse disposition of the punctæ in lines more or less coincident with the outline of the inner margin of the tooth. A medium size individual measures in greatest transverse diameter between the extreme angles of the inner margin 13 mm.; length along antero-lateral border 3 mm.

The above described forms are about equally numerously represented in individuals in the collections, although the specimens are in a more or less fragmentary state of preservation. The discovery by Mr. Van Horne of the mandible bearing the posterior pair of teeth, and showing the proximal articular extremity the right ramus and the somewhat produced, laterally narrowed extremity in the region of the symphysis, is the most interesting in connection with the genus. The semi-ossified tissue of the mandible in this instance seems to have remarkably intimate connection with the dental plates, and preserved in such a manner as to have the appearance of a cylindrical scroll, the inferior or inner margin being brought round to the exterior side, as the specimen rests in the limestone matrix. It forms a thin plate whose walls have been brought into contact by pressure, but posteriorly it probably shows its normal shape and dimensions, where it presents a crescentiform excavation with the condyloid or inferior process most produced posteriorly, the superior process relatively strongest. Anteriorly in the region of the symphysis, the mandible is less distinctly outlined. It is moderately produced and apparently obtusely rounded, the rami meeting at the symphysis but not anchylosed, and bearing either side a slight protuberance elongated parallel with the symphysical line, but without a vestige of the dental plates to which they afforded support. The latter more evidently of very small size, and if, as in *Cochliodus*, the distal extremity of the rami were armed with a median and anterior convoluted plate, their extreme diminutiveness may account for their absence in the collections. The same conclusion is also permissible in reference to the anterior dentary elements of the upper jaw.

Geological position and localities: St. Louis limestone; St. Louis, Mo.; Alton, Ill.; Pella, Iowa.

Pœcilodus Cestriensis, St. J. and W.

Pl. VIII. Fig. 15-17.

Teeth of medium or small size, mandibular posterior form having the general trapezoidal outline of *Cochliodus*, or a great transverse diameter compared with that in the direction of the strongly arched inrollment. Antero-lateral border comparatively short, a distinct furrow defining the narrow enamel fold from the shallow basal rim, sharply inrolled spirally at the extremity; inner margin very oblique in front, joining the articular border at a very obtuse angle, suddenly rounded at anterior ridge and more broadly so in passing the base of the principal ridge, moderately incurved in the intermediate space, and again on extending into the somewhat produced posterior angle; postero-lateral border moderately arched and rapidly converging toward point of inrollment, coronal enamel forming a relatively strong fold defined by a deep narrow sulcus from the inferior basal rim, which projects posteriorly beyond the coronal limits, terminating in a more or less produced spur. Anterior coronal ridge nearly as prominent but narrower than that behind, culminating in a sharply rounded crest with steep slopes descending to the antero-lateral border on the one hand, and into the deep, narrow median depression on the other; principal ridge situate about equidistant between the angles of the inner margin, broadly arched transversely over the inner third of its extent, but more sharply rounded in the outer portion, the posterior slope abrupt, and as in the parallel ridge somewhat deeply excavated; posterior depression broad and deep, the transversely slightly concave surface steadily rising into the wide posterior alation, which comprises about one-third the lateral diameter of the crown. Surface along the inner margin enveloped in a glassy enamel layer beneath which the minute densely crowded punctæ are distinctly visible, and which are laid bare over the greater area of the triturating surface in front; faint transverse undulations traverse the crown conforming to the curvature of the inner margin, worn specimens exhibiting more distinct irregular undulations along the crests of the coronal prominences. A specimen of ordinary size measures across the inner margin 16 mm..; length along principal ridge to inrolled outer margin, 10 mm.; length of anterior articular border, about 3.5 mm.

Maxillary posterior teeth subelliptical in outline, strongly inrolled at the outer margin. Antero-lateral border produced obliquely forward from the obtuse inner angle: postero-lateral border also obliquely and rapidly converging from the subacute posterior extremity towards inrolled margin, basal portion channeled and posteriorly expanding beyond the limits of the rounded, inbeveled coronal fold; inner margin strongly arched round the base of the posterior prominence, sharply contracted in front, and broadly arched round the anterior lobe to the antero-lateral border. Coronal region divided into nearly equal parts by the relatively narrow, deeply excavated median depression, posterior prominence regularly arched transversely into the broad rounded crest, which is interrupted by a few relatively strong, short transverse furrows and corresponding ridges extending over the outer half or more of its extent; anterior ridge also quite prominent with regular transverse convexity, and similarly marked by transverse corrugations. Surface generally minutely punctate. A specimen below medium size measures, in greatest diameter across the inner margin, 13 mm.; length along antero-lateral border, 8 mm., more or less.

Other associate forms of the species remain unknown; the small size of the recognized terminal teeth indicate for the unknown forms a diminutive size and delicacy that, in a measure, explains their absence in the collections, which, indeed, contain comparatively few individuals of either of the representative forms described above. The prominent transverse corrugations ornamenting the coronal ridges serve to distinguish the species from its congeners of the subjacent formations and subsequent deposits of the Coal Measures. In the latter respect, also, it presents quite as marked a contrast with the European species, originally distinguished under the names, *Pœcilodus Jonesii* and *Pœcilodus obliquus*, Ag.

Geological position and locality: Chester limestone; Chester, Illinois.

PŒCILODUS WORTHENI, St. J.

Pl. VIII, Fig. 18.

The Chester formation has recently afforded an example of a mandibular terminal tooth of *Pœcilodus*. This is referable to a species markedly distinct from all others known to me. The specimen was obtained, probably, from the limestone overlying the horizon from which the majority of the fish-remains of the Chester were derived, and is, thus far, a unique representative of its kind. The tooth belongs to the left ramus, and, besides its great size, it is distinguished by the following characteristics:

General outline trigonal, lateral diameter proportionately short, compared to the length, which it but little exceeds; general course of inner margin nearly at right-angles with the antero-lateral border, somewhat sinuous and broadly rounded, and somewhat sharply so in passing the angle of the principal coronal prominence, thence pursuing a slightly-curved course into the produced posterior angle; antero-lateral border nearly straight or very gently-curved sigmoidally in passing into the extremely-inrolled outer extremity; basal portion nearly vertical, very deep, and defined above by the usual narrow enamel fold, which forms an inbeveled coping projecting considerably beyond the basal wall; postero-lateral border rapidly converging toward the outer margin, making an angle of about 50° with the anterior border; condition of coronal fold and basal edge not determinable. Coronal region strongly arched in the direction of inrollment, and principally occupied by the longitudinal prominences; principal ridge nearly median, strongly arched transversely and defined by a more or less distinct angulation from the broad, posterior depression, which is bordered by the gentle acclivity rising into the postero-lateral border of the alate expansion; anterior ridge almost equally prominent and similar in contour to the principal ridge, from which it is separated by a deep depression of nearly equal breadth, with very steep, concave walls, slightly flattened along the rounded crest, the slope in front descending, in a similar slight concavity, to the antero-lateral border, which is margined by a very narrow fold of the coronal enamel. Surface minutely and densely punctate, with faint transverse lines along the less worn inner margin, otherwise destitute of the rugosities common to nearly all its congeners. Transverse diameter at the inner margin about 35 mm.; length of antero-lateral border to point of inrollment, 25 mm.; ditto along principal coronal ridge, about 30 mm.; depth of antero-lateral border, 5 mm.

The outer portion, as also the postero-lateral border, is mutilated, exposing to view the remarkable inrollment which amounts to one and a half revolutions, with a short convoluted apex. The form described differs in so marked a degree from other species of the genus as not to require detailed comparison; it is chiefly distinguished from allied species by the regularly arched coronal ridges, deep narrow median depression, and abbreviated transverse diameter.

This largest American representative of the genus, and I believe the largest species known, is dedicated to Professor Worthen, the venerable director of the geological survey.

Geological position and locality: Chester limestone, Chester, Ill.

Pœcilodus Springeri, St. J. and W.

Pl. VIII, Fig. 19.

The present species is made known from a few examples representing the posterior or terminal form of the mandible. The teeth attain medium size, strongly arched in the direction of inrollment. Antero-lateral border slightly oblique, outward and forward, to the general course of the inner margin, relatively short, basal border channeled; postero-lateral border converges towards outer inrolled margin at an angle of 50 more or less, with opposite border, basal portion unknown; inner margin strongly deflected backward from the very obtuse anterior angle, making an angle at the base of the anterior lobe, with a regular concavity in the region of the median depression, as also in passing the posterior depression into the acutely rounded posterior extremity, broadly arched round the base of the posterior or principal lobe. The characteristic contour features strongly marked in the coronal region; anterior lobe rising into a narrow sharply rounded crest, anterior slope slightly concave and defined by a narrow rounded fold inbeveled to the inferior or basal border; median depression deeply excavated and regularly concave transversely, marked by a few, three more or less, parallel longitudinal folds; posterior ridge more broadly arched transversely, prominent, abruptly declining into the deep posterior depression, which is bordered by the strongly upraised, broad alation. Surface, aside from the already mentioned longitudinal folds occupying the bottom of the median depression, smooth, and minutely and densely punctate, the puncta exhibiting a tendency to transverse disposition in lines parallel with the inner margin. Breadth between angles of inner margin 21 mm.; length along antero-lateral border 5 mm., or a trifle less than half the longitudinal diameter along the anterior lobe.

The above species, the representatives of which were discovered by Frank Springer, Esq., in whose honor the specific designation is given, offers resemblances almost equally intimate with the species described respectively from the St. Louis and Chester formations of the Upper Mississippi region, so far at least as may be judged by the comparison of the single representative form of the present species. The extreme obliquity or rather posteriorly produced inner margin in front of the anterior lobe, however, distinguished the form from *Pœcilodus St. Ludovici*, and the presence of longitudinal folds in the median depression offers a contrast with *P. Cestriensis*.

Geological position and locality: Lower Carboniferous limestone strata; vicinity of Santa Fe, New Mexico.

PŒCILODUS CARBONARIUS, St. J. and W.

Pl. VIII, Fig. 20-21.

Teeth of medium or small size, known from the opposed terminal forms of the upper and lower jaws.

Posterior teeth of the mandibles characterized by the relatively low coronal ridges, the principal ridge situate considerably posterior of a line traversing the middle of the tooth in the direction of inrollment, broadly arched transversely along the inner margin but forming a narrow angularly rounded ridge toward the outer margin; anterior ridge narrow, sharply rounded along the crest, steeply sloping to the articular border of the antero-lateral side, and nearly equally abruptly inclined behind into the comparatively wide median depression separating it from the principal ridge, and which is traversed by a slight longitudinal fold; posterior depression defined on the one side by the steep slope of the principal ridge, and on the other moderately rising into the comparatively narrow alate expansion of the postero-lateral border, which terminates in the moderately produced posterior angle; postero-lateral border nearly vertical or produced slightly outward inferiorly, defined along the upper edge by the narrow inbeveled enamel fold and slightly channeled; antero-lateral border not well shown in the accessible examples. Breadth of tooth across the inner margin 17 mm.; length of antero-latera articular edge 4.5 to 5 mm.; longitudinal diameter along principal ridge to inrolled outer margin about 13.5 mm.

Posterior teeth of the maxillaries in general outline elliptical, rather strongly and spirally inrolled, broadly arched outward along the inner margin with a slight concavity in the region of the median coronal depression; postero-lateral border terminating in a sharply rounded angle, thence gently and regularly curved in its rapid convergence toward point of inrollment, the relatively strong enamel fold inbeveled to the basal rim from which it is defined by a deep narrow groove; antero-lateral border very oblique outward and forward to the inner margin, and also apparently defined along the upper edge by a narrow inbeveled enamel fold. Coronal contour regularly and rather strongly arched longitudinally, moderately so transversely;

posterior or principal ridge occupying half the lateral diameter of the tooth, rather strongly convex transversely, posterior slope moderate and uniform to the postero-lateral border, opposite slope steeply descending with slight concavity into the narrow median depression which corresponds in the extreme obliquity to the course of the anterior articular border; anterior ridge culminating in a sharply rounded crest, toward the outer margin flanked by the nearly vertical, concave slope of the median depression, the border opposite declivity more gently descending to the antero-lateral border along which it is slightly depressed, and marked by faint longitudinal undulations, or sometimes interrupted plicæ which obliquely descend from near the crest toward the oblique anterior portion of the inner margin. Length of a specimen of ordinary size along the antero-lateral border about 6 mm.; transverse diameter at the inner margin 17 mm.

Triturating surface finely and closely punctate in both forms mentioned above, presenting the usual variations in accordance with the degree of abrasion to which the surface has been subjected. In crossing the narrow ridges the punctæ often show marked lateral elongation and disposition in parallel rows corresponding in course to the formative margin, besides the oblique and longitudinal folds already mentioned occurring in the anterior slope of the maxillary teeth; and in excessively worn surfaces the medulary layer is entirely removed, exposing to view the dense homogenous inferior layer of the dental structure.

Only a few specimens representing the above described forms have been obtained, associated in the same stratum at LaSalle; examples of probably specifically identical forms have come to our notice from other localities in Illinois and Kansas. The species offers characters readily distinguishing it from allied earlier appearing forms; the longitudinally ridged median depression and relatively narrow alate expansion of the mandibular terminal teeth, and the relative proportions of the coronal prominences and the peculiar undulations of the anterior slope in the maxillary teeth constitute the salient features contrasting the species with *P. Cestriensis*.

Geological position and localities: Upper Coal Measures; LaSalle, Ill., and Kansas. A single specimen has been obtained from the dark limestone twenty feet above Coal No. 6, near Belleville, and Mr. Butters has discovered the same remains in the roof shales of Coal No. 5 at Carlinville, this State.

GENUS DELTODUS, Agassiz.

Deltodus, AGASSIZ, MSS., 1859. *Pœcilodus sublævis;* Messrs. J. MORRIS and G. E. ROBERTS, 1862, Quarterly Jour. Geol. Soc. London, XVIII, p. 91; Messrs. NEWBERRY and WORTHEN, 1866, Illinois Geological Survey, II, p. 96; Lord ENNISKILLEN, 1869, Catalogue of Type Specimens, Geol. Mag., London, VI, extract, p. 4; Dr. L. DE KONINCK, 1878, Faune du Calcaire Carbonifère de la Belgique, II, p. 63; Dr. F. BIGSBY, 1878, Thesaurus Devonico-Carboniferous, 1878.

These forms have thus far been recognized as having probably pertained to one and the same generic category, as follows:

Mandibular posterior teeth sub-triangular or sub-spatulate in outline, arched and slightly spirally inrolled from within outward. Antero-lateral border with a slight concavity in its course from the inner angle to the inrolled outer margin, basal portion channeled and terminated below in a thin rim, bordered above by the inbeveled belt which is enveloped in the coronal enamel, and partaking of its punctate structure; postero-lateral border obliquely converging from the sub-acute posterior angle toward the outer margin, gently arched, nearly vertical, basal portion channeled and defined above by a narrower, more or less abruptly-rounded belt of coronal enamel; inner margin sigmoidally curved, broadly arched from the obtuse anterior angle round the base of the coronal prominence, with a concave course thence to the sub-acute posterior angle. Coronal region presenting a prominent anterior ridge culminating in a more or less rounded crest near the median line, with gentle inclination to the antero-lateral border, abruptly sloped into the posterior depression, which is defined by the more or less upraised border forming the posterior alate lobe.

Mandibular median teeth cuneate or elongate sub-trapezoidal in outline, relatively narrow, transverse diameter, longitudinally arched and inrolled at the outer margin. Postero-lateral border with a slight sigmoidal curvature and somewhat oblique outward and forward course, basal portion channeled and terminating in a narrow edge, coronal belt relatively wide, abruptly beveled to the narrow ridge limiting the basal furrow, the articular border nicely co-adapted to that of the conterminous posterior tooth; antero-lateral border relatively short, less oblique in its outward and forward course, basal portion relatively narrow, channeled, limited above by the rounded, inbeveled enamel fold; the inner margin is peculiar for the obliquity of the anterior half and sudden deflection nearly at right-angles in rounding the base of the coronal ridge, with a slight concavity in its course thence to the sub-acute posterior angle; coronal region traversed by a strong median ridge, culminating in a rounded crest, the slope terminating in a narrow depression, which is bordered by the more or less well-defined marginal fold along the anterior articular border, that behind merging into the wider depression which is bordered by the narrow, alate lobe of the posterior border. Other dental forms of the mandibles unknown.

Maxillary posterior teeth trigonal in outline, relatively longer and less strongly arched and inrolled than the opposed mandibular teeth. Antero-lateral border gently curved sigmoidally outward and slightly forward, proportionately low and inbeveled, defined by the narrow, rounded, inbeveled enamel fold, which is separated from the shallow basal rim by a narrow furrow; the postero-lateral border more obliquely converges toward the outer inrolled margin with gentle curvature, usually strongly inbeveled, the coronal enamel contributing a relatively wide belt inbeveled to the deep, more or less distinctly-channeled basal portion, which meets the inferior surface of the tooth in an obtuse angulation; inner margin very obliquely produced from the slight anterior angle to the base of the coronal prominence, where it is abruptly deflected with a slight concavity in passing the posterior coronal depression to the sub-acute posterior extremity. The anterior portion of the crown is occupied by a prominent ridge, the more or less rounded, sometimes angular crest, culminating nearest the antero-lateral border, to which it is steeply sloped, and defined by the shallow, depressed belt bordering that side; the opposite side presenting a wider, gently-convex, or concave slope, descending into the posterior depression, which is bounded by the more or less strongly-upraised posterior alation. The character of the anterior teeth associated with the above form has not been determined.

The superficial characters associated in common with the forms above noticed are subject to variations such as characterize the species they represent. While the normal condition of the crown is that of a smooth, finely and densely punctate surface, to these features certain species add narrow, impressed transverse sulci, which in others assume the magnitude of broad undulations crossing the crown parallel to the inner margin of the tooth. There are also, in certain species, more or less distinctly developed longitudinal plicæ or furrows, which are especially discernible in the less worn surface toward the inner margin.

The forms above alluded to have already been brought to the attention of naturalists, and their congeneric relationship conjectured. As early as 1859 Professor Agassiz had recognized the generic identity of the forms here referred to the posterior position upon the upper and lower jaws respectively, to which he then gave the name *Deltodus*, which was accepted by European authorities and recognized in various publications. Prior to the above date, Professor Frederick McCoy, in the British Palæozoic Fossils, 1855, recognized the probable identity of the narrow median teeth, here referred to the mandibles, with the so-called "anterior teeth" of *Deltodus sublævis*, which he described under the name *Pœcilodus parallelus*. The latter form presents the same general figure and coronal contour here ascribed to the median form, although at the same time it presents marked specific characters. Heretofore authors have not essayed the distinct definition of the dental elements pertaining to the upper and lower jaws of this genus, and in the attempt in that direction here initiated we are profoundly conscious of the meagre, imperfect data from which to draw evidence which shall not be open to objection on account of its inconclusive nature. However the facts are briefly stated, and if they do not carry conviction as to the justness of the interpretations arrived at they will at least show the difficulties in the way of the student who shall attempt the restoration of extinct forms from few and detached remains such as are represented by these teeth.

We are thoroughly satisfied with the conjecture of Professor McCoy as to the relative position and specific identity of the narrow median tooth, as above pointed out; but, on the other hand, the data do not sustain former inferences as to the position occupied by the form with which the narrow teeth were associated upon the jaw. The so-called "anterior" tooth possesses essentially the characteristics of the form which, in *Cochliodus*, is known to hold a posterior or terminal position upon the mandible. The latter form thus transposed readily lends itself to interpreting the median position of the succeeding narrow tooth, the articular walls exactly conforming in coadaptation, and thus placed they assume a symmetrical disposition perfectly in consonance with that characterizing the mandibles of *Cochliodus*, *Pœcilodus* and *Cestracion;* on the other hand, it is impossible to conceive of so intimate relations in the case of the so-called "terminal" tooth with either of the forms just alluded to. However, certain features are noticeable by which a certain striking resemblance is manifest between the median form and that here referred to the posterior or terminal position on the upper jaw (the "terminal" tooth of authors). This consists in the remarkably close similarity in coronal contour which obtains in either form alike, although in outline and general appearance they are so markedly different one from the other. A comparison of the forms reveals the same depressed or sulcated anterior slope of the principal coronal prominence, very oblique anterior portion of the inner margin and its abrupt deflection in passing around the base of the coronal ridge into the posterior extremity; even the articular edge of the anterior borders in the two forms is very like, but in the postero-lateral borders there is marked dissimilarity between them, nor have we been able to identify amongst the material before us forms with which the maxillary posterior teeth were associated. Whether the upper jaw was terminated by a series of teeth, such as undoubtedly occupied the anterior portion of the jaw in *Cochliodus*, it is impossible at the present time to more than conjecture.

The genus is represented by species thus far authentically reported only in lower Carboniferous formations in Europe, where it was the cotemporary of *Cochliodus*. In America, however, its representatives range from near the base of the lower Carboniferous (Burlington limestone), thence through the successive formations up into the Coal Measures. The following is a list of the species at the present time known, the affinities of the forms being recognized in accordance with the characteristics cited in the foregoing descriptions and observations:

Deltodus sublævis, Agass., mountain limestone, Great Britain. (—*Pœcilodus parallelus*, McCoy, and possibly *Pœcilodus aliformis*, McCoy.)

D. sandalinus, de Koninck, Carboniferous limestone, Belgium.

D. spatulatus, N. and W., U. Burlington limestone.

D. occidentalis, (Leidy—sp.) Keokuk limestone. (—*D. stellatus*, N. and W.)

D. undulatus, N. and W. Keokuk limestone.

D. latior, St. J. and W. Keokuk limestone.

D. Littoni, N. and W. Warsaw limestone?

D. cinctulus, St. J. and W. Warsaw limestone.

D. trilobus, St. J. and W. Warsaw limestone.

D. parvus, St. J. and W. St. Louis limestone.

D. intermedius, St. J. and W. St. Louis limestone.

D. cingulatus, N. and W. Chester limestone.

D. Mercurii, Newb. Lower Carboniferous.

D. Powellii, St. J. and W. Upper Carboniferous.

D. propinquus, St. J. and W. Coal Measures.

Deltodus latior, St. J. and W.

Pl. IX, Fig. 11-12.

Mandibular posterior teeth moderately arched longitudinally and rather strongly inrolled, in general outline and dimensions resembling the same form of *Deltodus occidentalis* with which they are associated. Antero-lateral border slightly incurved, in length exceeded by the breadth across the inner margin, enamel fold defined from the basal border by a shallow groove; general course of inner margin slightly oblique to the anterior border, broadly arched round the base of the coronal prominence with a slight concavity between the median and the posterior angles; postero-lateral border gradually converging toward the outer margin. The upper edge defined by a rather thick fold of the coronal enamel. Coronal ridge most prominent in the middle portion of its extent, depressed near the inner margin, culminating in an obtusely rounded crest a little anterior of the median line, anterior slope flat or slightly depressed, posteriorly steeply inclined into the depression on that side, which is bordered by the rather wide moderately upraised alate expansion. Surface punctation very like that observed in *D. occidentalis*. Length of a medium size tooth along the antero-lateral border to inrolled outer margin 15 mm.; breadth across inner margin 19 mm.

The posterior form of the mandible alone is known, of which the collections contain but few examples. These present, in the contour of the crown and proportions of the coronal prominence and alate lobe, characters which certainly offer striking contrast to those prevalent in *Deltodus occidentalis*, with whose remains they are associated. The same observations are equally admissible when compared with the same form of *D. undulatus*, N. and W., also of the Keokuk, and *D. spatulatus*, N. and W., of the Upper Burlington limestone. In the depressed anterior slope and the consequent greater or less prominence of the coronal ridge, these teeth bear some resemblance to the homologous form of *Cochliodus;* however, the condition of the coronal fold of the antero-lateral border as also the coronal contour leave no room for doubt as to their congeneric relations with *Deltodus*. The paucity of examples and the absence of identifiable individuals of the opposite jaw have occasioned much hesitation in recognizing the specific distinctness of the teeth here alluded to; the materials illustrating *D. spatulatus*, *D. occidentalis*, and *D. undulatus*, ample and variable in their bounds as they are, do not make it clear that the present form is but a varietal phasis of one or other of the last mentioned species.

Geological position and localities: Keokuk limestone, near Warsaw and Hamilton, Ill.; Keokuk, Iowa.

DELTODUS CINCTULUS, St. J. and W.

Pl. IX, Fig. 6, 7.

Teeth below medium size. Mandibular posterior tooth triangular in outline, lateral diameter relatively broad compared to the length, and somewhat strongly inrolled at the outer extremity. Antero-lateral border nearly at right angles with a line connecting the inner angles of the tooth. The upper half or more of its height enveloped in the strong, inbeveled enamel fold, beneath which the basal portion forms a narrow rim showing a coarse vascular structure; inner margin with a slight sigmoidal curvature, broadly arched round the base of the coronal ridge, with a moderate concavity in passing the posterior depression into the posterior angle; postero-lateral border gradually converging toward the outer margin, occupied by a well-defined enamel fold extending nearly half the depth, basal portion slightly channeled and terminating in a narrow rim inferiorly. Coronal ridge relatively broad, strongly arched laterally, culminating a little anterior of the median line, with a gradual slope into the posterior depression from which rises the relatively narrow, slightly upraised alate lobe which terminates in the sub-acute posterior angle; in mature or somewhat worn specimens where the surface has been deprived of the original enamel investment, the crown is undulated by sub-equal transverse folds and intervening narrow sulci conforming to the bands of elongate punctæ that mark the order of increment of the tooth substance. Breadth of an ordinary-sized specimen at the inner margin, 11.5 mm; length of antero-lateral border to point of inrollment, about 9 mm.

Posterior tooth of the upper jaw trigonal in outline, moderately arched in the longitudinal direction. Inner margin making a sigmoidal curvature from the posterior sub-acute angle, broadly rounded into the antero-lateral border with which it is more or less oblique; anterior articular edge unknown; postero-lateral border gradually converging toward the outer extremity; enamel fold well defined and separated from the basal portion by a narrow channel. Coronal prominence relatively narrow, culminating about midway of the anterior half of the coronal region, abruptly descending to the antero-lateral border, gently sloping into the broad, shallow posterior depression, which together with the slightly upraised wing occupies a proportionately wide extent of the coronal area. Surface marked by sub-equal and more or less parallel transverse folds, separated by narrow furrows similar to the opposed mandibular teeth, and conforming to the curvature of the inner margin. A medium size tooth measures in greatest transverse diameter at the inner margin about 11.5 mm; greatest length from posterior angle to outer inrolled margin, about 16 mm.

The species above noticed is closely allied to its congeners of the *Deltodus undulatus* type. The mandibular posterior teeth are, however, distinguishable by their relative great breadth at the inner margin, as compared to the length; the narrow wing expansion recalls more the condition prevalent in *D. occidentalis*, from which, however, it may be recognized by its broader, shorter form and undulated coronal surface. The opposed maxillary teeth bear a striking resemblance to *D. cingulatus*, N. and W., of the Chester limestone, differing, however, in the greater obliquity of the inner margin and, perhaps, the more numerous transverse sulci, producing the banded appearance of the crown surface, while the more widely expanded wing, and the greater obliquity of the inner margin, also serve to distinguish them from *D. undulatus*, N. and W.; also, in both forms of the present species the punctæ are perceptibly more crowded than is the case in *D. cingulatus*, and in which respect they again resemble *D. undulatus*.

As yet the collections contain very few examples of the teeth above referred to, but these, besides their small size, offer characters which seem to authorize the recognition of their distinct specific standing, although closely allied to the species with which they have been compared.

Geological position and localities: Warsaw beds: Barrett's Station, St. Louis Co., Mo.; Madison county, Piasa creek above Alton, and Scott county, Ill.

DELTODUS TRILOBUS, St. J. and W.

Pl. IX, Fig. 8.

Mandibular median tooth of medium size, wedge-shaped in outline, moderately arched and rather strongly inrolled. Postero-lateral or oblique border converging toward the outer extremity at an angle of about 15 with the opposite border, slightly sigmoidally curved from the sub-acute inner angle to point of inrollment, basal portion of moderate depth, rather deeply and angularly channeled, the inferior rim produced downward and slightly outward beyond the limits of the enamel fold, which latter forms a wide belt abruptly beveled above, with an inbeveled narrow strip below; antero-lateral border proportionately short, or hardly more than half the length of the opposite articular border, the rounded anterior coronal lobe inbeveled to the relatively shallow-channeled, inbeveled (?) basal rim; inner margin very obliquely produced backward from the very obtuse anterior angle to the broadly rounded base of the principal coronal ridge, thence to the posterior angle, making nearly a right angle to its anterior course, with a slight concavity in the region of the posterior depression. The principal ridge occupies half or more of the transverse diameter of the coronal region, rising into a high, rounded crest, the anterior slope steep and terminating in a narrow depression outwardly defined by the rather prominent, rounded lobe traversing the antero-lateral border; the opposite slope is very abrupt, with slight transverse concavity, merging into the rather deep posterior depression, which is bordered by the prominent alate lobe of the postero-lateral border. Coronal surface smooth, the inner margin preserving the thin enamel coating, the worn surfaces exhibiting fine, closely arranged punctæ. Breadth of tooth at inner margin about 10 mm; length along the oblique border to point of inrollment 14 mm.

The above description is based upon a single nearly perfect tooth, the antero-lateral border being slightly distorted by pressure. Compared with allied species, it is readily distinguished from the mandibular median form of the Keokuk and Upper Burlington species, *Deltodus occidentalis* (Liedy, sp.) and *D. spatulatus*, N. and W., by the distinct lobed condition of the anterior border; also, the alate lobe is more prominent than in *D. spatulatus*, and less expanded than occurs in *D. occidentalis*.

So far as relates to the present unique example, little doubt can arise as to its specifically distinct character; but as regards the forms with which it was specifically associated, the meagerness of the material hardly furnishes a clue as to their identity. Thus far, the Warsaw limestone has afforded only a few fragmentary remains of *Deltodus*, some of which certainly are very intimately related to the Keokuk species *D. occidentalis* (maxillary and mandibular posterior forms); but the imperfect state of preservation of these specimens offers nothing definite bearing on their specific identity, as noticed in another place. We are satisfied that the species of *Deltodus* are, in some instances at least, extremely intimately related to one another, although distinguishable by well-defined peculiarities, as exhibited by ordinarily well-preserved examples. However, amongst the mass of material—like that including *D. occidentalis* and *D. undulatus*, of the Keokuk limestone—it is impossible to recognize the specific identity of the fragmentary individuals, and the same state of things undoubtedly obtains in respect to allied representative species.

Messrs. NEWBERRY and WORTHEN have described (Ill. Geol. Surv. IV, p. 367, Pl. IV, f. 8) a maxillary terminal form under the name *Deltodus Littoni*, reported from the Carboniferous limestone of Boone county, Missouri. It is uncertain whether the latter, which is represented by an unique example, was derived from the Warsaw or from the St. Louis formation, both of these formations, as also the Keokuk, etc., occurring in the region indicated; however, the appearance of the limestone matrix does not suggest the latter horizon, and it is supposed the specimen belongs to either the Warsaw or the St. Louis. We owe to the courtesy of Dr. LITTON, of St. Louis, the privilege of examining the type specimen. It is a large, much-worn tooth, neither border of which is sufficiently complete to permit of detail comparison with allied species. The relative great breadth and regular convexity of the coronal ridge and apparently narrow posterior alation, offer marked contrast to the prevalent Keokuk species *D. occidentalis*, bearing a greater resemblance to *D. undulatus*, especially, compared with worn examples of the latter species, in which the transverse undulations are more or less obscured, or obsolete. It is possible the narrow median tooth described above may be specifically identical with the latter form, in which event, of course, the name by which it is here designated will have to give way to the prior term bestowed by Messrs. NEWBERRY and WORTHEN.

Geological position and locality: Warsaw limestone; Jersey county, Illinois.

DELTODUS OCCIDENTALIS? (Leidy, sp.)

Pl. IX, Fig. 9-10.

Compare *Deltodus occidentalis*, (Cochliodus occidentalis), Leidy, 1856, Trans. Am. Phil. Soc., XI. (2d ser.)

Deltodus stellatus, NEWBERRY and WORTHEN, 1866, Ill. Geol. Sur., II. p. 97, Pl. IX, f. 3-4.

The collection from the Warsaw and St. Louis formations contain rare examples of the teeth of both the mandibular posterior and median forms and of the maxillary posterior form of a species closely allied to, if indeed it proves not to be identical with, *Deltodus occidentalis*, (Leidy sp.) so numerously represented in the Keokuk limestone. The Warsaw specimens, of which a single example of the posterior tooth of the upper and lower jaws respectively has been obtained, though fragmentary, present so close a resemblance to the Keokuk species that were their stratigraphical derivation not known they would without hesitation be relegated thereto. The maxillary tooth (Warsaw) does not show quite as angular coronal ridge, but in the outline and coronal contour in other respects it is most intimate in its relations with that species. The mandibular tooth (Jersey county) preserves only part of the middle or elevated portion of the tooth, the borders and extremities being mutilated, showing the general characteristics save the longitudinal ridges attributable to the Keokuk teeth. In size they are a little larger than the prevailing dimensions attained by the teeth of that species. The St. Louis specimens are even more like the Keokuk teeth so far as it is possible to judge from the few examples thus far obtained. The collection of Mr. Van Horne contains a fragment of the mandibular posterior tooth, from Alton, and Prof. Worthen has obtained from the same horizon in Monroe county, an almost entire, though somewhat crushed and distorted, example of the opposed tooth belonging to the left ramus of the upper jaw, in which the keel along the crest of the coronal ridge is well shown. The character of the punctæ is also very similar to the Keokuk teeth, both of the specimens here alluded to being a little under medium size as compared with the Keokuk examples.

Mr. Van Horne has obtained from the Warsaw beds in the neighborhood of the mouth of Piasa creek, above Alton, two specimens of the maxillary terminal form, but, unfortunately, they are in too imperfect a state of preservation for the satisfactory determination of their specific identity. They are quite peculiar for the exceedingly crowded punctation, and one of the specimens shows quite distinct widely spaced transverse undulations traversing the coronal surface, recalling *Deltodus cingulatus*, N. and W., of the Chester limestone.

The Warsaw beds at Warsaw have also yielded a large example of the mandibular median form, which is difficult to distinguish from the same form associated with *Deltodus occidentalis*, except that the principal ridge is very perceptibly more broadly rounded or depressed along the crest and the alate lobe relatively stronger and a little more prominent; the antero-lateral border is broken away so that it is not clear how closely it resembles the typical examples of the species with which it is here compared as well as its resemblance to the form referred to under the head of *D. trilobus*, from which it differs in its more robust build and less emphasized coronal prominence.

The specific identity of the teeth above alluded to, if it proves to be well founded, is of enhanced interest on account of the evidence they furnish on the perpetuation of the species unchanged for so long a period as that involved in the deposition of probably not less than 300 feet of sediments included between the earlier and the latest deposits in which its remains have been found, while other species subsequently appear both in the Warsaw and St Louis formations.

Geological position and localities: Warsaw limestone; Warsaw, Alton, and Jersey county, Ill.: St. Louis limestone; Alton, and Monroe county, Ill.

DELTODUS PARVUS, St. J. and W.

Pl. IX, Fig. 1-5.

Teeth of small size. Mandibular posterior form sub-trapezoidal in outline, rather strongly arched and inrolled, usually a little longer than wide. Antero-lateral border with a slight incurved outline, basal portion slightly channeled and limited above by the narrow enamel fold; inner margin forming nearly a right angle with the anterior border, broadly rounded with a slight sigmoidal curvature on nearing the slightly produced posterior angle of the alation; postero-lateral border gradually converging toward the outer margin and bordered by a rather strong fold of the coronal enamel. Crown broadly arched over the principal ridge, which occupies two-thirds or more of the entire area, posteriorly rapidly sloping into the depression on that side, which is bordered by the relatively narrow, slightly upraised alate expansion. The surface is interrupted by transverse sulci, especially noticeable near the border in the anterior slope and in the posterior depression, and minutely and uniformly punctate. A worn specimen of ordinary size measures in length along the antero-lateral border about 7 mm.; greatest breadth across inner margin, 8 mm.

Maxillary posterior teeth trigonal in outline, strongly arched and spirally inrolled. Antero-lateral border describing a gentle sigmoidal curvature, basal portion channeled and well defined from the strongly inbeveled coronal fold, which constitutes about one-third the height of the border; postero-lateral border gently arched, approaching point of inrollment at an angle of about 70° with the opposite side, relatively deep, basal portion slightly inbeveled to the inferior edge and faintly channeled, enamel fold relatively wide and sharply rounded above, inbeveled below; inner margin making an angle of about 30° with the anterior border, the anterior half very obliquely produced backward from the very obtuse anterior angle, rounded and sharply deflected at the inner angle or base of the coronal ridge nearly at right angles to the anterior course, with a slightly concave curvature in passing the posterior depression to the posterior angle, worn specimens showing the usual inbeveled inferior edge. Coronal contour strongly marked, principal ridge culminating in the rounded crest a little anterior of the longitudinal median line; anterior slope steep, slightly depressed near the articular border, where it flares out into a narrow border fold; posterior slope regularly descending with moderate concavity, and merging into the posterior depressed belt, which is bordered by the narrow and but slightly upraised expansion of the alate posterior border. Besides the irregularly elongated pores, the surface is marked by transverse sulci and intervening wider ridges in the same manner noticed in the mandibular teeth. A mature, perfect tooth measures across the inner margin 9 mm.; length along antero-lateral border to the inrolled outer margin, 7 mm.; length along coronal axis, 13 mm.

The present species is represented by several examples of the mandibular and maxillary posterior forms, whose perfect state of preservation permits of detail comparison with allied species. It bears most intimate relations with *Deltodus cinctulus* of the Warsaw beds, the mandibular teeth being chiefly distinguishable by the proportionately greater breadth of the principal coronal ridge, narrower posterior wing, and the more numerous transverse furrows and ridges; in the case of the maxillary posterior form, it contrasts with that of the above species in the relatively more prominent coronal ridge, narrower alation, abrupt deflection in the course of the inner margin, and the less conspicuous, narrow transverse undulations traversing the coronal region.

A single imperfect specimen of a minute tooth obtained by one of the writers at St. Louis, is provisionally identified with the narrow median form of the mandible of the present species. Partaking in an intimate degree of the outline and coronal contour of the median teeth characteristic of the genus, as it is now interpreted, its small size suggests relationships with the specific forms above alluded to. It shows the prominent, rounded coronal ridge, narrow alate postero-lateral border, and the still narrower and shorter articular border of the opposite side, but the mutilated condition of the specimen does not disclose the distinctive specific characters that distinguish it from congeneric forms.

Geological position and localities: St. Louis formation; Pella, Iowa; Alton, Illinois; St. Louis, Missouri.

DELTODUS INTERMEDIUS, St. J. and W.

Pl. IX. Fig. 14, 15.

Teeth attain medium size. Maxillary posterior form sub-triangular in outline, rather strongly arched and inrolled. Antero-lateral border slightly curved sigmoidally, articular edge very narrow, inbeveled to the slightly channeled, shallow basal rim; postero-lateral border converging toward inrolled outer margin at an angle of 35° with the opposite side, somewhat undulated, the relatively thick enamel fold sharply inbeveled to the channeled, posteriorly expanded basal rim, which is rather strongly produced at the subacute, rounded posterior angle; inner margin strongly produced inward and slightly backward from the very obtuse angle at the junction of the anterior articular border, suddenly deflected nearly at right angles and broadly arched round the base of the coronal ridge, with a slight concavity in the region of the posterior depression, inferiorly inbeveled. Coronal ridge relatively narrow, steeply rising from a faint depressed line near the anterior edge, crest rounded, gradually descending into the posterior wide depression, which is bordered by the moderately upraised alation. Surface nearly smooth, with obscure transverse lines along which the punctæ exhibit elongated or otherwise enlarged openings, rarely anything like undulations appearing. Length along crest of coronal ridge to inrolled outer margin about 31 mm.; length of anterior articular border 18 mm.; greatest breadth across inner margin 21 mm.

The collections from St. Louis horizons afford a solitary authentic example only of the present form, the nearly perfect tooth above described. This is quite distinct from the earlier-occurring species, and offers striking resemblance in coronal contour with the smooth individuals of *Deltodus cingulatus*, N. and W., of the Chester formation. It is, perhaps, distinguishable from the latter species by the somewhat less produced posterior angle, less elevated coronal ridge, and shorter articular edge of the antero-lateral border. A single other imperfect example has been obtained by Mr. Van Horne from the same formation at Alton, Illinois, which represents the mandibular posterior form possibly of the same species. The fragment indicates a tooth of a relatively long, narrow outline with a rather oblique inner margin in front, a broad gentle slope descending from the crest of the coronal ridge to the deep, inbeveled coronal fold of the articular border, the opposite flank abruptly descending into the posterior depression; the alation, as also the outer margin of the tooth, is broken away.

Geological position and localities: St. Louis formation; Pella, Iowa, Alton, Illinois.

DELTODUS POWELLI, St. J. and W.

Pl. X, Fig. 1.

Teeth attain medium size. Mandibular terminal form subspatulate in outline, moderately arched longitudinally and rather strongly inrolled at the outer margin. Antero-lateral border gently incurved, enamel fold strongly inbeveled to the channeled basal rim; postero-lateral border gradually converges toward outer inrolled margin, making an angle of about 23° with the anterior border, the rounded, inbeveled enamel fold well defined by a narrow sulcus from the shallow basal portion, which is somewhat expanded posteriorly; inner margin broadly and regularly arched round the base of the coronal prominence from the obtuse anterior angle, with a rather deep concave course in the region of the posterior depression, joining the posterior border in a subacute angle, inferiorly inbeveled. Coronal ridge prominent, occupying the anterior two-thirds of the area, and culminating in the broadly rounded crest a little anterior of the median line; anterior slope regularly convex, the posterior declivity more abruptly descending into the relatively narrow posterior depression, which is defined by the narrow, moderately upraised, rounded alate lobe. Surface traversed by well-marked, widely spaced transverse furrows, especially noticeable in the coronal prominence, which are occupied by irregular transversely elongated pores, below intervening undulations showing minute, widely spaced punctæ. Length of anterior articular border at least 17 mm; breadth across the inner margin 20 mm.

The unique example above described was obtained by Maj. POWELL's expedition to the Grand cañon of Colorado, from the Carboniferous limestone. With the exception of the outer extremity, the specimen is quite entire, admitting of satisfactory comparison with allied forms. Of the latter, it is, perhaps, most intimately related to *Deltodus cingulatus*, N. and W., of the Chester formation, being distinguished chiefly by its proportionately greater breadth compared to the length of the tooth, narrower and more widely spaced transverse sulci, and narrower alate lobe. It also differs from *D. Mercurii*, Newb., in the same respects relating to the diametral dimensions and in the distinct transverse undulations of the coronal region,—indeed, the only feature which it shows in common with that species being the narrow posterior alation.

We have described in another place, under the specific designation *Deltodus propinquus*, a fine large species from the Coal Measures of Illinois, which, so far as relates to the homologous form, bears most intimate resemblance with the present tooth. The only appreciable distinctions by which the latter teeth may be distinguished consist in the greater obliquity of the inner margin and the undulations traversing the crown,—indeed, worn examples, in which the longitudinal undulations are obsolete, are hardly recognizable from the tooth above described.

The specific designation is given in honor of Major J. W. POWELL, U. S. Geologist, in charge of the geographical and geological exploration of the Rocky Mountain region. The unique type is deposited in the National museum, at Washington, the loan of which, for examination, was kindly procured us by Dr. CHARLES A. WHITE.

Geological position and locality: Carboniferous limestone, probably of the age of the Coal Measures; Grand cañon of the Colorado, Utah territory.

DELTODUS PROPINQUUS, St. J. and W.

Pl. X. Fig. 3, 4.

Mandibular posterior teeth sub-trigonal or sub-spatulate in outline, rather strongly arched longitudinally, with slight, spiral inrollment. Antero-lateral border sigmoidally curved, strongly inbeveled, and occupied by a wide enamel fold, which is sharply defined by a deep, narrow furrow from the extremely narrow basal rim; postero-lateral border converging, at an angle of 35° more or less, to the opposite border, also gently curved, coronal enamel forming a prominent, rounded fold, inbeveled to the sulcated, moderately deep basal rim, which was apparently continued posteriorly into a spur-like angle; inner margin sigmoidally curved, broadly arched around the base of the coronal prominence, in breadth exceeding the length of the anterior articular border, inferiorly inbeveled. Coronal prominence occupying three-fourths of the area, rather strongly convex laterally, broadly rounded along the crest, which lies a little anterior of the median line, the wide anterior slope rounded into the anterior border, posteriorly steeply inclined into the narrow depression on that side, defined along the posterior border by the narrow, rounded, moderately-upraised alate lobe. Coronal surface traversed by rather strong, irregularly-spaced, transverse undulations and longitudinally marked by less distinct plications; the dense, polished enamel also presents a delicate rugose appearance, the minute rugæ having a longitudinal direction; worn surfaces over the outer portion of the crown reveal the usual pitted structure, the punctæ becoming confluent, or usually longitudinally elongated in the hollows of the transverse undulations. A large tooth shows a transverse diameter across the inner margin of 35 mm; length of anterior articular border from the obtuse inner angle to the point of inrollment, about 27 mm.

Mandibular median form known only from a couple of fragments, too imperfect for figuring. It is characterized by the prominence of the anterior lobe, which presents a rounded crest defined on either side by exceedingly abrupt declivities, on the one hand descending to the anterior border which is margined by an obscurely defined narrow fold strongly inbeveled to the deeply-channeled basal rim, and on the other merging into the posterior depression, whose postero-lateral border is broken away, as also the inner and outer portions of the tooth. The form was evidently sub-cuneate in outline. The coronal surface exhibits the same punctate characters noticed in connection with the terminal form; however, the transverse undulations are less conspicuous. The relative size agrees with the preceding form with which it was associated.

Posterior tooth of the upper jaw elongate triangular in outline, rather strongly arched from within outward, and spirally inrolled. Anterior articular border comprising, perhaps, two-thirds of the greatest length of the tooth from the inrolled outer margin to the very produced inner angle at the base of the principal coronal ridge, gently curved sigmoidally, the narrow enamel fold strongly inbeveled to the deeply-channeled, shallow basal rim; postero-lateral border converging at an angle of 45°, more or less, with the anterior articular border gently curved, the thick enamel fold rounded and sharply inbeveled to the correspondingly deep, flaring basal border, from which it is defined by a deep sulcus; inner margin making a slight angle with the articular border in front, suddenly deflected nearly at right angles in rounding the base of the coronal ridge, and thence passing to the posterior angle with a slight concavity in the region of the posterior depression, worn specimens inbeveled inferiorly. Principal coronal ridge culminating in a rather sharply rounded crest about one-fourth the distance from the anterior border, presenting a steep convexity descending to the shallow depressed belt bordering the articular fold, on the opposite side gently descending into the wide posterior depression from which abruptly rises the narrow, transversely arched alate expansion, and from which it is defined by a distinct augulation. The coronal surface is more or less regularly undulated transversely, producing a nodose appearance along the crest of the principal ridge. The character of the delicately rugose enamel enveloping the inner portion of the crown, and the punctation of the outer worn surface, is precisely as observed in the opposed teeth of the mandible. In both forms, also, the smooth or faintly longitudinally striated inferior surface approximately conforms to the contour of the coronal region, showing the usual dense thin basal layer. Length of a large tooth along the anterior articular border to inrolled outer margin, 32 mm. or more; greatest length of tooth along the crest of the coronal ridge, 58 mm.; breadth between inner angles of the tooth, about 51 mm.; ditto, between base of coronal ridge and the sub-acute porterior angle, 39 mm.

The above diagnoses are based upon examples of the mandibular, posterior and median forms, and the posterior form of the upper jaw, derived from lower Coal Measure strata of Illinois. The species is intimately allied to that occurring in the Chester formation, *Deltodus cingulatus*, N. and W. The mandibular terminal form, however, is distinguishable by its stouter proportions, wider coronal ridge, and relatively shorter longitudinal diameter. The opposed teeth of the upper jaw, again, differ from the corresponding Chester form in the more prominently transversely arched alation, in which particular it bears closer resemblance to *D. undulatus*, N. and W., of the Keokuk limestone, from which, however, it widely differs in the more angularly rounded contour and concave posterior slope of the principal coronal prominence. The Coal Measure forms of the Upper Mississippi region, therefore, constitute a well defined species, as distinguished from the several specific groups occurring in the various formations of the Lower Carboniferous groups in the same region. Its intimate resemblance to the species described from the (probably) Coal Measure limestone of the Far West, *D. Powellii*, has already been remarked upon. It is possible that a larger suite of specimens of the latter species might prove its specific identity with the present teeth; but this can only be demonstrated by the comparison of all the forms.

Geological position and localities: The first example of the present species that was brought to our notice, several years ago, was discovered by Mr. L. A. Fuller in the shales overlying Coal No. 7, at Danville. Subsequently, Mr. Alexander Butters obtained from the roof shales of Coal No. 5, at Carlinville, representatives of all three of the forms thus far identified as pertaining to this species.

GENUS DELTODOPSIS,* St. J. and W.

Teeth possessing coronal contour and general aspect near *Deltodus*.

Mandibular posterior teeth distinguished by their oblique sub-triangular outline and the remarkable obliquity of the anterior portion of the inner margin, proportionately short extent of the anterior articular border, the sometimes longitudinally depressed condition of the anterior slope of the coronal prominence, and the tendency to produce a more or less well defined median ridge along its sum-

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*In allusion to a resemblance to *Deltodus*.

mit. The antero-lateral and postero-lateral borders are marked as in *Deltodus*. The coronal fold of the articular border, perhaps, more rounded and relatively narrower than that of the postero-lateral border.

Teeth, identified with the median form of the mandible, are characterized by their thin, oblique, trapezoidal figure, great length of the posterior, as compared with that of the anterior, articular border, and its strong outward and forward obliquity. The basal rim and enamel fold corresponding in co-adaptation with the opposed border of the posterior or terminal tooth, and essentially like the thinner and very short antero-lateral border; inner margin very oblique from the subacute posterior angle forward to the obtuse anterior angle; coronal surface comparatively plain, or culminating in a low ridge near the posterior side.

The maxillary posterior teeth are characterized by their elongate, wedge-shaped outline, narrow inner margin, and the narrow posterior alation. The postero-lateral or oblique border shows the basal portion inbeveled, channeled, and defined above by a distinct, inbeveled enamel fold; the opposite articular border is relatively short and mostly enveloped in the enamel fold, beneath which projects the narrow basal rim; the inner margin, as in the corresponding form of *Deltodus*, is very oblique in its course from the very obtuse angle of the articular border backward to the base of the coronal ridge, where it is abruptly deflected at right angles, thence to the posterior extremity. The crown presents a simple prominence or ridge along the anterior side, with abrupt slope to the articular border, and behind, descending into a shallow depression, from which rises the narrow wing expansion.

The superficial punctation is very like that observed in *Deltodus*, with similar specific modifications.

There exists so intimate relationship between the forms here alluded to and typical *Deltodus* that we have hesitated in recognizing for them more than a subgeneric distinctness. But taking into consideration the community of characteristics by which they are distinguished, and which equally serve to distinguish them from *Deltodus*, this discrimination seems to be founded in tangible superficial characters that fail not to impress the observer with their importance. The greater the familiarity with the various examples embraced under this group, the differentiation, or tendency thereto, of the median ridge of the anterior coronal prominence further widely departs from typical *Deltodus*, while at the same time it marks an unmistakable approach to the coronal condition of certain forms near *Cochliodus*, e. g. *Chitonodus Springeri*, etc. Of other dental forms which were associated with the above-mentioned teeth of the mandible and upper jaw, respectively, we are at the present time at a loss to determine their character or identity.

Authentic examples of the forms here associated together have been derived from the Warsaw, St. Louis and Chester formations; certain forms representing mandibular posterior teeth have also been obtained from the Keokuk formation, but their relations with the present genus are not as satisfactorily shown as in the case of the later introduced forms alluded to. *Deltodus angustus*, N. and W., of the Chester limestone, which was originally described from examples of the elongate posterior teeth of the upper jaw, is regarded as a typical representative of the present genus.

Through the courtesy of Lord Enniskillen we have had opportunity to compare the American forms with sketches of a large "palate" from the Carboniferous limestone of Oreton in Shropshire, England, which seems to be congeneric with the teeth above grouped together, and the monarch of its kind. Possessing the same outline and general contour of coronal region attributable to the maxillary posterior teeth of *Deltodopsis*, the Oreton example is distinguished by its truly gigantic proportions, and, perhaps, also by its relatively narrow lateral diameter and the very steep declivity descending to the antero-lateral border. The tooth from which the above mentioned sketch was made represents the posterior angle of the wing rounded, as though from wear. The specimen measures in greatest length nearly 9 centimetres, breadth across the inner margin about 4 centimetres.

DELTODOPSIS AFFINIS, St. J. and W.

Pl. XI, Fig. 1.

The species here alluded to is represented by a solitary example of the posterior tooth of the mandible. Comparison reveals most intimate relationship with the species occurring in the St. Louis formation, *Deltodopsis St. Ludovici*. It is characterized, however, in contradistinction to that species, by the relatively great breadth of the posterior depression and wing expansion, the narrower and distinctly transversely depressed anterior slope of the coronal prominence. The coronal surface is worn, so that the punctæ appear somewhat coarser and more regular, while the transverse undulations are very like what occurs in the latter species. Length from the inner angle of the coronal ridge to the inrolled outer extremity, about 11.5 mm; greatest breadth across inner margin, 9 mm.

As yet other forms which were probably associated with the above tooth have not been recognized. Indeed it is only within a recent date that the Warsaw beds have afforded many fish remains, and in most instances these represent forms peculiar to the formation.

Geological position and locality: Warsaw shaly limestone, Golden Bluffs, near Warsaw, Ill.

Deltodopsis St. Ludovici, St. J. and W.

Pl. XI, Fig. 2-6.

Mandibular posterior teeth depressed, triangular in general outline, moderately arched longitudinally and inrolled. Antero-lateral border comprising a little more than one-third the extent of the tooth along the coronal ridge, gently curved from within outward, basal rim slightly furrowed and bordered by the distinct, narrow, inbeveled enamel fold; inner margin in front diverging at a slight angle from the anterior angle to the base of the coronal ridge, round which it is sharply curved with a slightly concave course to the acute posterior angle of the alate expansion, inferiorly inbeveled; postero-lateral border gently arched, gradually converging toward the suddenly inrolled outer extremity, the narrow inbeveled enamel fold distinctly defined from the nearly vertical channeled basal border. Coronal prominence culminating in an obtusely rounded ridge near the median line, anterior broad slope nearly plane or slightly convex, more abruptly sloping into the depression on the opposite side, which is bordered by the moderately upraised narrow alate expansion of the postero-lateral border. Crown surface minutely and somewhat irregularly punctate, unworn surfaces showing numerous delicate transverse furrows parallel with the inner margin and producing a slight undulated appearance; in some examples the exfoliated enamel reveals a surface delicately striated by wavy threads holding the same course as the undulations. A tooth of medium size measures along the articular anterior border to point of inrollment 8.5 mm; transverse diameter across inner margin 13.5 mm; length along crest of coronal ridge 19 mm.

Mandibular median tooth subtrapezoidal in outline, moderately arched longitudinally, outer extremity strongly inrolled spirally forward. Postero-lateral border gently curved conforming to the opposed articular border of the terminal tooth, basal border deep, inbeveled, double-furrowed, terminating inferiorly in a narrow rim, and bordered above by the relatively strong, rounded, inbeveled, enamel fold; antero-lateral border relatively very short. The enamel fold inbeveled to the channeled basal border and constituting more than half the height of the border; inner margin making a slight sigmoidal curvature from the acutely rounded posterior angle to the obtuse anterior angle, inferiorly inbeveled in worn examples. Coronal surface nearly plane transversely, culminating in a low, obscurely defined ridge close upon and parallel with the postero-lateral border, the broad anterior slope merging into the very shallow depressed belt traversing the anterior portion of the coronal area; surface marked by distinct transverse undulations and furrows parallel with the inner margin, inner edge enveloped in a dense enamel coating, immediately forward of which the worn surface exhibits irregular verrucose markings, and over the much worn outer half the usual punctate structure appears, the punctæ displaying marked tendency to irregular elongation in various directions, in all which particulars the teeth bear most intimate resemblance to the associated forms of the species. A mature tooth measures across the inner margin 7.3 m m; along the postero-lateral border to point of inrollment about 10.5 m m; antero-lateral border about 4 m m.

Maxillary posterior teeth narrow triangular or subcuneate in outline, gently arched longitudinally. The anterior portion of the inner margin diverges at a very slight angle with the antero-lateral border, or making nearly a right angle with the portion behind the abruptly rounded base of the coronal ridge, slightly concave in passing the posterior depression into the slightly produced posterior angle; postero-lateral border very gradually converging toward the outer extremity, which is suddenly inrolled; both the antero and the postero-lateral borders are marked by the narrow enamel fold, inbeveled to the channeled basal border, which latter in the anterior border is exceedingly shallow compared with its greater inbeveled depth in the posterior border. Coronal prominence rising abruptly from the antero-lateral border, regularly arched transversely, more gently descending into the posterior depression, which is traversed by a faint angulation defining the inner limits of the narrow and somewhat sharply upraised posterior wing. Surface markings agreeing with what has already been observed in relation to the opposed mandibular teeth, even to the details of the irregular punctation and undulations and the delicate transverse tracery observed in partially exfoliated surfaces, especially of the wing expansion. A specimen of the ordinary size measures in extreme length along the coronal crest 23 mm; antero-lateral border about 16 mm; breadth across inner margin 8 mm.

The present species is of peculiar interest on account of the facts it affords in relation to specific diferentiation and the intimate resemblances that exist between the individuals of allied species. Thus, compared with the Chester form there exists markedly close resemblance between the mandibular posterior teeth, the chief distinction in the present form being its, perhaps, less oblique inner margin, the peculiar coronal ornamentation and less regular punctate structure. But in relation to the maxillary posterior teeth of the two forms, a marked difference is apparent, the present form being relatively much more elongate longitudinally and proportionately narrower, while the proportionately narrow, plane or slightly convex anterior slope contracts with the wide, gently concave declivity characteristic of the Chester teeth.

Geological position and localities: St. Louis formation; Pella, Iowa, Alton and other localities in Madison and Monroe counties, Black's Hill, Hardin Co., Ill., St. Louis, Mo.

DELTODOPSIS ANGUSTUS, (N. and W., sp.)

Pl. XI, Fig. 7-10.

Deltodus angustus, NEWBERRY and WORTHEN, 1870, Ill. Geol. Surv. IV, p. 368, Pl. iii, f. 7.

Maxillary posterior teeth subcuneate in outline, very moderately arched longitudinally, except at the inrolled extremity. The antero-lateral articular border comprising somewhat more than half the extreme length of the tooth, defined by the thick, rounded enamel fold, which is strongly inbeveled to the shallow, channeled basal rim; inner margin very obliquely produced backward from the obtuse anterior angle, where it unites with the antero-lateral border, sharply arched round the base of the coronal ridge, with a slight sigmoidal curvature thence to the posterior angle nearly at right-angles to the anterior portion; postero-lateral border gently curved from a right line, very gradually converging toward the inrolled extremity; coronal enamel forming a very narrow, inbeveled fold, well defined from the shallow-channeled deep basal border, which is usually inbeveled,—probably in perfect specimens nearly vertical, or slightly produced beyond the coronal limits posteriorly. Anterior ridge occupying more than half the transverse diameter of the coronal surface, transversely arched, abruptly sloping in front to the anterior articular border, more gently declining into the posterior depression from which the suddenly-upraised, narrow alate lobe is defined by a distinct angulation. Surface minutely and closely punctate, and further marked by more or less distinct transverse undulations conforming to the inner margin, usually obsolete over the greater extent of the coronal region. A specimen of ordinary size shows a length along the coronal ridge of about 28 mm; transverse diameter at the inner margin, 11 mm.

Posterior tooth of the mandible proportionately agreeing in size with the opposed maxillary teeth, trapezoidal in general outline, of great transverse diameter at the inner margin as compared to the length along the antero-lateral border, strongly inrolled and arched longitudinally. Antero-lateral border obliquely produced outward and forward from the obtuse inner angle, enamel fold forming a narrow, rounded belt inbeveled to the slightly-channeled basal rim, which it equals in depth; inner margin very obliquely produced backward from the anterior angle, broadly arched round the base of the coronal prominence with a slight concavity in passing the posterior coronal depression into the moderately produced, acutely rounded posterior extremity, inferiorly inbeveled; postero-lateral border very rapidly converging toward the outer inrolled margin, gently curved and nearly parallel with the anterior half of the inner margin, the narrow, rounded enamel fold inbeveled and defined by a slight sulcus from the basal portion, which forms a shallow rim projecting downward and outward well beyond the coronal border,—in worn examples inbeveled. Crown traversed nearly centrally by a rather prominent regularly transversely arched ridge, the broad slope descending to the antero-lateral border, somewhat depressed, more abruptly sloping into the posterior depression, beyond which rises the moderately upraised alate expansion of the postero-lateral border. Surface closely and regularly punctate, mature individuals, especially those in which the exterior layers have been exfoliated, showing more or less distinct crowded rugæ parallel with the inner margin of the tooth. In both of the above described forms a tendency to compression or elongation of the punctæ is observable, in the transverse furrows presenting a very delicate tracery in some specimens. A specimen of ordinary size measures across the inner margin 18 mm.; length of antero-lateral border to the inrolled outer margin, 8 mm.

The dozen or so examples of each of the above described forms contained in the collections, offer facilities for acquiring a somewhat comprehensive understanding of their characteristic features, which are remarkable for their persistency, the individuals presenting comparatively slight variation among themselves. Although associated in the same strata, in every instance thus far observed the teeth occur as isolated specimens disconnected from their original position in relation to one another. Therefore, in regard to the assumed specific identity of the forms here alluded to, the presumptive evidence is precisely the same as allowed in the association of forms in other specific groups, the justification of which is derived from what is known in relation to the diverse dentition of *Cochliodus.* In the present species, however, we are as yet unable to determine the character of the teeth holding anterior positions upon the jaws. In the case of the mandibular terminal or posterior teeth, the relatively short articular border necessitates a corresponding abbreviated longitudinal diameter for the tooth immediately in advance; and so, also, as regards the maxillary teeth, which latter may have been associated with teeth whose form bears the remotest suggestion of their relationship with the teeth described.

Geological position and locality: Chester limestone, Chester; and near Columbia, Monroe county, Illinois.

DELTODOPSIS? CONVOLUTUS, St. J. and W.

Pl. XI, Fig. 11-12.

Teeth obliquely subtrigonal in outline, strongly arched from within outward, with strong spiral inrollment. Antero-lateral border making a gentle sigmoidal curvature in its slightly oblique forward and outward course, basal portion very deep, broadly channeled, terminating below in a narrow rim, and bordered above by the rounded, inbeveled enamel fold which constitutes about one-third the height of the border; postero-lateral border converging at a variable angle of 50° to 70°, mature individuals being relatively narrower than medium, and small-sized teeth, obliquity somewhat greater than that of the opposite side, basal portion deep and rather deeply channeled, the lower edge expanding posteriorly beyond the rounded, inbeveled enamel fold, which envelopes the upper third of the height of the border; inner margin making a slight sigmoidal curvature from the obtuse anterior angle to the base of the coronal ridge where it is suddenly deflected nearly at right angles to its longer anterior course, gaining the posterior extremity in a slightly concave course and nearly at right angles to the postero-lateral border. Coronal region traversed by a prominent, sharply rounded ridge culminating a little more than one-third the distance from the posterior border, to which the moderately concave slope abruptly descends, margined by the very narrow alation, the broad anterior slope more gradually declining with gentle transverse concavity in the vicinity of the antero-lateral border. Surface more or less distinctly undulated transversely, the dense enamel layer toward the inner margin as also the worn area marked by impressed, irregularly-spaced lines of growth parallel with the inner margin; punctation fine and close. A small perfect tooth measures across the inner margin 11 mm.; length of antero-lateral border to inrolled outer margin 7 mm.

The above description refers to a form of peculiarly massive strongly involute teeth of which there are several well-preserved examples in the collections before us. In regard to the specific relations of these teeth with other known forms, the facts offer little beyond conjecture. So far as relates to the superficial coronal features they offer no appreciable contrast with *Deltodus spatulatus*, N. and W.; but the value of these resemblances it is impossible at the present time to determine. In the present instance we have no evidence such as, in the case of *Cochliodus*, enables the grouping together of divers dental forms with, to say the least, strong presumptive evidence in support of the interpretations relating to their probable arrangement upon the jaws. On the contrary, with respect to the detached remains of *Deltodus* and *Sandalodus*, although unquestionably partaking of true cochliodont characteristics, the student must be guided by their general similitude supplemented by critical familiarity with the external structural features which two or more species possesses in common, the persistence of which may be inferred from what is known to occur in *Cochliodus* and immediately allied genera; in order to detect even the possible specific relations of the forms met with. Viewed in this light the association of the present form with the supposed mandibular posterior teeth of *Deltodus spatulatus* seems highly improbable. The strong spiral inrollment and the comparatively narrow, rounded enamel fold of the articular border, are not in consonance with the corresponding features of the latter form; hence it does not displace the inferred relations of the median form ascribed to that species, and which was originally described as the "third" in the series to which the name *Cochliodus costatus* was given by Messrs. Newberry and Worthen.

Viewed from a standpoint taking cognizance of such features as they possess in common, the form here alluded to offers marked resemblance, in the co-adaptation of the articular borders, to the form described by Messrs. Newberry and Worthen as the "second" tooth of *Cochliodus costatus*. Essentially the same contour and reversed curvature of the articular borders obtain in the two forms which are otherwise unusually like in coronal contour, so much so indeed as rather to lead to the conclusion that they are distinct species of the same representative form, so little do they differ one from the other in outline and contour; while in *Cochliodus* the mandibular median tooth widely differs in both these respects from the posterior teeth with which it was associated. Also, there is an appreciable difference in the punctation of the forms here referred to, that of "*Cochliodus costatus*" being coarser and more irregular, and the general surface contour more uneven and rugged.

We are at a loss to assign the form here particularly alluded to to any of the recognized generic groups. The extreme inrolment of the outer extremity and the obliquity of the posterior lateral border do not suggest intimate relations with the median teeth of *Cochliodus*; on the contrary, these features, together with the general outline and conformation of the coronal region, are more consistent with the Deltodi, perhaps having closest generic relations with [illegible], with the mandibular posterior teeth of which it agrees in the obliquity of inrolment, [illegible] and character of the lateral borders.

Geological position and localities: Upper Burlington limestone; fish-bed strata. Burlington, Pleasant Grove, Burlington, [illegible] County, Iowa; Quincy, Ill.

[illegible]

[illegible]

Teeth [illegible] inrolled. [illegible] angle [illegible] articular [illegible] arched [illegible] compared with the relatively thin antero-lateral edge, presenting a deep, slightly channeled, inbeveled belt bordered above by the thick, rounded enamel fold; inner margin making an angle of about 30° with the anterior articular border to the base of the coronal ridge, where it is abruptly rounded and deflected nearly at right angle to its anterior course with a slight concavity in passing the posterior depression to the subacute posterior angle. Coronal contour strongly marked by the elevated ridge which culminates in a rounded crest overhanging the deep, narrow posterior depression, the wide anterior slope presenting a slight transverse concavity; posterior alation forms a rounded lobe well defined from the groove-like posterior depression. Surface showing more or less distinct longitudinal plicæ in the less worn enamel layer toward the inner margin, and traversed by transverse lines and faint undulations; punctæ fine, crowded, showing tendency to conform in their disposition to the transverse lines.

The collections afford only two examples of the above described form, neither of which are sufficiently perfect to permit accurate measurement of their dimensions, although sufficiently so to allow satisfactory comparison with allied species. In size and general outline it agrees with its predecessor, *Deltodopsis? convolutus*, of the Upper Burlington limestone, from which it is distinguished by its appreciably more robust build, and especially by the overhanging crest of the coronal ridge or the inflexed slope descending into the narrow posterior depression, and the distinctly lobed condition of the alation.

Geological position and locality: Keokuk limestone; Warsaw, Illinois.

DELTODOPSIS ? EXORNATUS, St. J. and W.

Pl. XI. Fig. 14.

Teeth small, subtrigonal in outline, strongly arched longitudinally, and very strongly inrolled spirally. Antero-lateral border proportionately short, basal portion channeled and bordered by the thickened, inbeveled enamel fold; postero-lateral border rapidly converging toward outer inrolled margin; inner margin, from the obtuse anterior angle, very obliquely deflected backward in a slightly concave curvature, abruptly rounded at the base of the coronal ridge, with a shallow concavity thence to the posterior angle; coronal ridge prominent, the sharply rounded crest culminating nearest the postero-lateral border, from which it is separated by a relatively narrow intervening depression, which is bordered on the one hand by the low, narrow alation, and on the other by the abrupt posterior slope of the coronal ridge, the wide anterior slope descending with gentle concavity to the narrow raised fold along the antero-lateral border. Surface regularly marked by strong transverse ridges or undulations spaced by narrow grooves parallel with the inner margin, and enveloped in a dense enamel layer, the worn areas showing coarse, widely-spaced punctæ. Transverse diameter across the inner margin about 8 mm.; length of antero-lateral border to joint of inrollment, about 4 mm.

The form above noticed is represented in the collection of Mr. Van Horne by a single specimen, the postero-lateral border of which is broken away, so that the entire outline of the tooth is not shown. In general outline and coronal contour, it bears intimate resemblance to a congeneric form of the Upper Burlington, *Deltodopsis* (?) *convolutus;* it may, however, be distinguished from that form by the greater obliquity of the anterior portion of the inner margin, the probable greater width and more distinct definition of the posterior alate lobe, and the strong transverse undulations of the crown to which it owes its ornate character.

Geological position and locality: Warsaw limestone; north of Piasa creek, above Alton, Illinois.

DELTODOPSIS ? BIALVEATUS, D. ? KEOKUK, and D. ? CONVEXUS.

Pl. XI, Fig. 15-18.

Teeth wedge-shaped viewed from above, moderately arched in the direction of inrollment. Lateral borders deep, very gradually converging from within outward with a slightly oblique course; basal portion proportionately very deep, channeled above, with a wide slightly inbeveled belt below, terminating in a more or less sharply rounded rim defining the excavated and sometimes longitudinally furrowed inferior surface, defined above by the relatively narrow, rounded, inbeveled enamel fold; inner margin obliquely and gently rounded from the obtuse anterior (?) angle to the subacute angle of the oblique border; coronal belt sharply inbeveled to the deep, slightly produced basal portion. Coronal region usually a little narrower than the base, which extends slightly beyond the limits of the enamel fold in the lateral borders, the worn outer surface presenting a simple lateral convexity, but in the middle and toward the inner margin showing more or less distinct, subangular sulci separated by a low median ridge. Surface marked by more or less distinct lines of growth parallel with the inner margin, and coarse, irregular and irregularly elongate or confluent punctæ. A medium-size tooth measures across the inner margin 5 mm.; greatest length along the obligue border to point of inrollment, 11 mm.; vertical depth at middle, 4-5 mm.

The foregoing diagnosis presents the normal condition of a peculiar form of teeth which is represented by half a dozen, more or less, perfect examples in the collections from the Upper Burlington fish-bed. In two of these examples the inner half of the crown shows a simple shallow depressed area defined by the slightly raised border folds, while a third specimen shows throughout a simple transverse convexity of the coronal surface. The latter variety also possesses a narrower basal support, and in both f its peculiarities it agrees with a solitary example in Mr. Springer's collection from the upper or beds of passage fish-bed of the same formation. The latter horizon has also afforded Mr. Springer a second specimen which is undistinguishable from the variety described above.

Only two or three examples of this form have thus far been detected in the Keokuk limestone, above which it has not been recognized. The latter teeth are very like the typical specimens described above, showing a similarly double-furrowed coronal surface, the only marked distinction consisting in the greater size and more robust figure of the Keokuk teeth.

In consequence of the meagre data relating to this form it is difficult to determine the character of the variations alluded to—whether they are of specific or merely varietal importance. In the accompanying description of the figures illustrating the several varieties the following provisional terms are employed to distinguish them: *Deltodopsis? bialveatus, D.? convexus, D.? Keokuk.*

In the attempt to assign the present form to its proper generic relations we are met at the outset by the difficulties incident to the meagerness of the material for the purposes of comparative examination. The further characterization of the form discloses a slight spiral inrollment, the direction of which indicates that the oblique border is apparently homologous with the postero-lateral border of typical Cochliodonts, and with this character is also associated the obliquity of the inner margin from the posterior angle to the obtuse anterior angle, and the somewhat marked flaring of the inferior basal rim on the side corresponding to the antero-lateral border;

therefore, it is evident the form held a median, possibly an anterior, position probably on the mandible. It remains to ascertain its probable associate forms, and here again we are met by the insufficiency of .our understanding, which hardly more than suffices vague suggestion. All the individuals alike of all the varieties exhibit a peculiar broad undulate uneven course in the borders of the teeth, which toward the outer inrolled margin usually takes the form of a more or less distinct sudden constriction or narrowing of the coronal region. A very similar character is noticeable in the form previously described by Messrs. Newberry and Worthen under the name *Cochliodus costatus*, "second tooth," in which the lateral borders are similarly widely undulate and narrowed towards the outer margin, where the strongly inrolled extremity has lost its coronal enamel presenting the appearance of having been embedded in the integument of the jaw, precisely as observed in the form here particularly noticed. Further, there is a somewhat striking resemblance between the latter forms in respect to the peculiar character of the punctation and the rugged surface of the crown, and the relative great depth of the lateral border, although in the present form, apparently, the depth of the borders is even proportionately greater than is the case in "*C. costatus*" ("second tooth). Beyond this we have not the materials for a more satisfactory comparison, but it seems to us not improbable the latter forms originally formed parts of the dentition of one and the same species.

Geological position and localities: Upper Burlington limestone; Burlington, Augusta, Buffington creek, Louisa Co., Iowa; Keokuk limestone; Warsaw, Ill.

GENUS TOMODUS, Agassiz.

PSAMMODUS, Agassiz, 1838, Poissons Fossils III.; TOMODUS, Agassiz, Mss.; 1859, etc.

The genus *Tomodus*, Agassiz, founded upon the species *T. convexus* of the British Mountain limestone, is known to us by one or two imperfect examples of the large strongly arched form contained in the collections of the Museum of Comparative Zoölogy, Cambridge, which, however, do not afford so satisfactory means of comparison as might be desired in the definition of their generic characteristics. We are, however, indebted to the courtesy of Lord

Enniskillen, for the opportunity to examine sketches of the two forms of the type species, from the Mountain limestone of Bristol, England, belonging to the Museum at Florence Court, which, so far as relates to general outline and coronal contour, convey a tolerably distinct impression of the peculiarities distinguishing the genus.

The latter sketches exhibit examples of two forms, the one and apparently that occurring most abundantly, represents an elongate tooth below medium size, trapezoidal in outline, with very gradually converging lateral borders, and moderate convexity from within outward. The straight or antero-lateral border presents an abrupt face with a sharp angulation above, and which seems to be enveloped by an enamel belt; the oblique border appears to be defined by a narrow rounded enamel fold inbeveled to the basal rim, which expands somewhat beyond the limits of the coronal border, terminating in the subacute posterior angle; the inner margin is apparently very gently, sigmoidally curved between the obtuse anterior angle and the posterior extremity, or nearly at right angles with the antero-lateral border. The crown shows moderate transverse convexity of the principal prominence along the straight border, the slope somewhat steeply descending into the posterior depression, which is bordered by the narrow upraised alation. The second form of teeth alluded to under the same specific designation, is represented by medium-sized examples, trigonal in outline, and strongly arched longitudinally. The antero-lateral or straight border is abruptly truncated, apparently vertical, and bordered by a belt of coronal enamel, basal rim not clearly definable; the oblique border is gently curved, rapidly converging toward the outer extremity, character of enamel fold and basal rim not discernible; inner margin broadly and regularly arched between the inner angles, apparently nearly at right angles with the straight border. Coronal region occupied by the very prominent anterior ridge, which forms a slight convexity extending from the sharp angulation along the straight border posteriorly over two-thirds and more of the transverse area of the crown, where the slope abruptly descends to the oblique postero-lateral border, which shows a very narrow, obscurely defined alation. In both of the forms above noticed the coronal surface is minutely punctate, the punctæ not arranged along distinct transverse lines. A specimen of the narrow elongate form measures in length along the straight border about 17 mm.; breadth across the inner margin 11 mm.; lateral borders converge toward the outer extremity at an angle of about 25°. A large example of the trigonal form measures in length along the straight border 31 mm.; breadth across inner margin 27 mm., more or less; lateral borders converge at angles of 30° to 40°.

The above notices of the forms associated by Professor Agassiz under the specific designation *Tomodus convexus*, will, perhaps, also serve to convey a tangible idea of the distinctively generic characteristics ascribable to the genus *Tomodus*. Its relations are most intimate with *Xystrodus*, from which it chiefly differs in the conspicuous convexity of the coronal ridge, the extremely abrupt articular border, and the absence of transverse disposition of the punctæ of the triturating surface. Our knowledge of the genus is so imperfect that we may have overlooked important generic characters, which the specimens themselves might reveal at a glance. Viewed in accordance with the facts elicited from the data within reach, we are led to suspect some confusion exists in the interpretations of the limits of the genus, and that in consequence forms have been referred to it which have no intimate congeneric relationship with *Tomodus convexus*. Of the latter, the species described by Dr. L. de Koninck in his great work on the Belgian Carboniferous limestone fauna,* under the names *Tomodus Craigi*, and *T. laciniatus*, certainly show a wide departure from the typical species *T. convexus*, Ag., while their relations with *Psephodus* are strongly suggested to judge from the admirable figures illustrating the Belgian teeth. The specific identity of the two forms ascribed to *T. convexus* may be also reasonably questioned, since both have the general conformation of mandibular teeth, and it is difficult to conceive how they could have been associated on the same jaw.

The American form mentioned in this connection, and which is provisionally referred to *Tomodus*, is the sole representative of the genus thus far brought to light in the Carboniferous formations of this country. The genus is Carboniferous, restricted so far as is known to the earlier group of the series.

TOMODUS? LIMITARIS, St. J. and W.

Pl. XIII, Fig. 12.

Teeth small, longitudinally elongate, cuneiform in outline, rather strongly arched in the direction of inrollment. Antero-lateral border gently curved sigmoidally from the obtuse inner angle to the

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*Faune du calcaire carbonifère de la Belgique, Première partie, 1878, p. 60.

[illegible] relatively deep and strongly inleveled [illegible] which is also leveled in the worn ex- [illegible] postero-lateral or oblique border [illegible] undulated, converging at an angle [illegible] with the opposite border, enamel fold rounded and [illegible] paralleled basal border; inner margin [illegible] the base of the coronal prominence, with slight [illegible] passing the coronal depression to the sub-acute poste- [illegible] Coronal ridge occupying nearly half the anterior coronal area, prominent, gently convex along the broad crest, steeply sloped into the posterior depression, where it is defined by a slight impressed angulation, posterior alation scarcely elevated along the outer border. Surface punctation comparatively coarse, irregular, the surface toward the inner margin being transversely undulated and enveloped in the dense enamel layer. Inferior surface gently concave, smooth. Breadth across inner margin, 5 mm; greatest length, 10 mm.

The unique example furnishing the foregoing description shows a nearly entire, though somewhat worn, tooth, representing, perhaps, the posterior form of the left ramus of the upper jaw. Its relations appear to be near *Xystrodus*, from which, however, it widely departs in the rounded condition of the enamel fold along the straight border, and especially in the coarse, irregular punctæ, which show no sign of arrangement in parallel transverse rows. There also exists some likeness to the teeth mentioned under the head of *Deltodopsis* (?) *convolutus*, from the same formation, so far as relates to the character of the punctæ and appearance of the surface enamel; but the tooth in question is not homologous with the supposed maxillary posterior form of typical *Deltoptychius*, as evidenced by the quite different character of the anterior articular border. In outline, the tooth equally resembles *Tomodus*, as represented by authentic examples of *T. convexus*, Ag., and this resemblance is even extended to the coronal contour; but we are not sufficiently familiar with the character of the articular border in the latter genus to be able to determine its exact relations with the form here particularly referred to. It is, therefore, with no certain convictions as to their congeneric relations that this example is provisionally placed in the above genus.

Geological position and locality. Upper Burlington limestone, fish-bed; Pleasant Grove, DesMoines county, Iowa.

GENUS XYSTRODUS, Agassiz.

XYSTRODUS, Agassiz, Mss., 1859 (COCHLIODUS STRIATUS, Ag. Poiss. Foss. III, p. 174; XYSTRODUS ANGUSTUS, Ag. Mss., 1859.

The genus *Xystrodus* was recognized by Professor Agassiz in 1859, to which he transferred the species previously described under the name *Cochliodus striatus*, Ag., from the Carboniferous limestone of Ireland. The later term was accepted by European palæichthyologists, and at a later date, 1869, was published in the list of type specimens of the magnificent collection at Florence Court, belonging to Lord Enniskillen, as also in the lists of the British Museum and and other institutions, and incorporated in the great work by Dr. Bigsby, the "Thesaurus Devonico-Carboniferous."

In accordance with the presumptive determinations and nomenclature adopted in the present work; the original or type of the genus *Xystrodus striatus* is referable to the maxillary posterior form, and notwithstanding the opposed mandibular teeth have been obtained from the same horizons and localities affording the former, we are not aware of their having been specifically identified and described. The latter teeth are recognizable by the extreme alation of the postero-lateral border, giving to the general figure excessive breadth compared to the length in the direction of inrollment.

The above-mentioned teeth agree in all essential features with the forms occurring in the various American Lower Carboniferous formations. Especially is this notable in the case of the Chester teeth *Xystrodus verus*, which indeed constitutes a typical representative of the genus. Therefore, from such materials as we possess, the following diagnoses of the opposed terminal teeth of the upper and lower jaws are prepared; of the other dental forms with which they were associated during the life of the fish to which they belonged, as yet we have failed to arrive at even a surmise as to their character.

Mandibular posterior teeth distinguished by their triangular outline and great transverse breadth of the inner margin as compared with the longitudinal diameter. Coronal surface occupying the entire superior area of the tooth, comparatively plain, more or less concave, or with a longitudinal depression, the coronal prominence crowded to the anterior side, nearly flat or but gently convex transversely, at the opposite border terminating in the expanded, upraised [illegible]. Antero-lateral border slightly curved sigmoidally, presenting an abrupt declivity from the angularly rounded upper edge, beneath which the coronal enamel forms a well defined belt, sharply limited by the basal portion, which latter projects downward, forming a narrow rim along the inferior edge; postero-lateral border rapidly diverging from the outer extremity, terminating in the more or less produced posterior angle, the upper edge enveloped in the narrow enamel fold, which is distinctly defined from the inferior basal border; inner margin making a moderate sigmoidal curvature, varying in obliquity to the antero-lateral border, with which it may form a right-angle.

Maxillary posterior teeth characterized by the relatively narrow transverse diameter at the inner margin, and consequent wedge-shaped outline. General contour of the coronal region resembling that of the opposed mandibular teeth, the principal prominence extending along the antero-lateral border, slightly convex or plane transversely, more or less steeply sloping into the longitudinal median depression, which is bordered on the opposite side by the upraised narrow wing expansion terminating in the posterior angle; antero-lateral border gently curved sigmoidally, more or less abruptly, sometimes vertically, sloping from the angular superior edge at the junction with the crown, the enamel forming a belt well defined from the basal border which terminates inferiorly in a thin rim; the opposite side gradually converges from the posterior angle toward the outer extremity, the upper edge enveloped in a distinct, narrow enamel fold, and defined by a slight channel from the equally shallow basal border; inner margin oblique in one or other direction to antero-lateral border, with which it also sometimes forms a right-angle.

The triturating surface in the typical species of both the above described forms presents a fine transverse striated appearance, produced by the arrangement of the punctæ in more or less parallel rows, conforming in direction to the course of the inner margin. However, the latter feature is not observed as a persistent one over the entire extent of the coronal region, even in the typical species, while in others it is but obscurely apparent, and in some species presumably otherwise agreeing with the typical forms, the surface presents no vestige of the transverse striation, on the contrary exhibiting the usual dense punctate structure common to the generality of the Cochliodonts.

The genus as herein defined offers intimate relationship with the genera *Deltoptychius* and *Orthopleurodus*, especially in the conformation and the distribution of the coronal enamel of the mandibular posterior teeth; but in other and essential characteristics it presents unmistakable features removing its forms from any of the groups of teeth of contemporaneous genera with which they are associated. At the same time we are cognizant of the diversity of the dental armature of the jaws of the Cochliodonts, and the "missing links" which are required in most instances before the restoration of the dentition of these genera can be consummated. But the teeth at present under consideration do not seem to fall into any such recognized combination, as evidenced not only by their peculiar contour, but also by the peculiar superficial structure observed in the typical representatives of the genus, and which is not found in connection with the teeth of other genera occurring in the same geological horizons. Hence, notwithstanding only the more conspicuous elements of the dentition of this genus are, at present, known, these are marked by peculiarities which seem to warrant the recognition of their distinct generic standing.

While we have not the data necessary for carrying the comparisons to a final conclusion, we are much impressed by the intimate resemblances which subsist between the present genus and *Tomodus*, Agass. A series of careful sketches of authentic examples of *Tomodus convexus*, Agass., from the Mountain limestone of Bristol, England, and which were kindly submitted to us by Lord ENNISKILLEN, show this relationship in a striking manner. The genus *Tomodus*, indeed, appears to be a *Xystrodus* in all save the arrangement of the punctæ in parallel transverse lines; and in the latter respect we find a close, though not absolute agreement, in the initial species occurring in the American Carboniferous species *X. simplex*.

Thus far ascertained, the genus *Xystrodus* is met with in both the great divisions of the Carboniferous period. One of the writers, in 1877, described in Dr. HAYDEN's final report on the U. S. geological survey of Nebraska (p. 241, Pl. IV, f. 18), a tooth under the name *Xystrodus? occidentalis*. The examination of subsequently acquired and more complete suites of the fish-remains of our Coal-Measure strata, from the upper division of which the latter specimen was derived, has led us to relegate that particular specimen to the genus *Orthopleurodus*, it probably being a very worn example, showing only a part of the inner portion of a mandibular posterior tooth of the species *O. carbonarius*, (—*Deltodus angularis*, N. and W.)

XYSTRODUS SIMPLEX, ST. J. and W.

PL. VIII, FIG. 4, 5.

Teeth of the mandible [illegible], rather strongly arched from within outward. Antero-lateral border very slightly curved, presenting an [illegible] from the sharp angulation above, and enveloped in a rather deep fold of the coronal enamel which is more or less distinctly defined from the deep basal rim; inner margin forming nearly a right angle with the anterior border, gently sigmoidal in contour with a shallow concavity in the region of the coronal [illegible]; postero-lateral border converging toward point of inrollment at an angle of 25 to 30 with the opposite border, coronal enamel forming a narrow rounded fold inbeveled to the shallow basal rim. Coronal prominence slightly convex transversely, bordered by the abrupt angulation along the antero-lateral side, rather steeply sloped posteriorly where it is more or less distinctly defined by a slight angulation, or merges into the broad posterior depression, which is bordered by the steeply upraised alation. Surface showing ordinary punctate structure over the worn areas of the crown, but revealing no distinct arrangement in transverse parallel rows, in which respect these teeth depart most widely from the typical species of the genus. Greatest breadth across the inner margin, 7.5 mm.; length along antero-lateral border, 8.5 mm.

Mr. Springer's collection contains a single specimen of a long narrow tooth which is supposed to represent the posterior form pertaining to the upper jaw. In general coronal contour it is very like the above described form of the mandible, showing the same abrupt antero-lateral border, with, however, a relatively narrow enamel fold, less steeply upraised alation and more gradually converging postero-lateral border, which makes an angle of 20° with the opposite border. The coronal punctæ show faint traces of transverse disposition, in which particulars it approaches the typical species of *Xystrodus*. Length of tooth along antero-lateral border about 11.5 mm.; breadth at inner margin about 7 mm.

The forms above described, which were doubtless associated upon the jaws of the same species, while they hold most intimately to the outline and coronal contour ascribable to *Xystrodus*, as illustrated both by the type *X. striatus*, Agass., of the Mountain limestone of Ireland, and the equally typical forms from the Lower Carboniferous of America, offer in contrast the absence of distinct transverse arrangement of the superficial punctæ. But, as has been mentioned, the maxillary posterior tooth shows obscure indications of parallel transverse disposition of the punctæ, though it is not nearly to the same degree apparent as in the typical species of the genus.

The present species bears a somewhat striking resemblance to *Tomodus convexus*, Agass., of the Mountain limestone of Great Britain. As has been already intimated, there would seem to be very intimate relationship between *Xystrodus* and *Tomodus*, the forms of both, especially the mandibular posterior teeth, showing the same outline and contour of the crown, and chiefly distinguished one from the other by the presence or absence of transversely disposed punctæ. In the present species the very obscure indications of the disposition of the punctæ in rows parallel with the inner margin of the teeth might be regarded as a transitional feature connecting the more widely differentiated species which are accepted as the typical representatives of one or other of the above named genera.

Geological position and localities: Upper Burlington limestone, fish-bed; Buffington creek, Louisa county; Burlington and Augusta (Iowa); Monmouth, Illinois.

XYSTRODUS INCONDITUS, St. J. and W.

Pl. VIII, Fig. 1.

Teeth very small, or below medium size, somewhat strongly arched from within outwards. Antero-lateral border nearly straight, or presenting the usual slight sigmoidal curvature, vertical, meeting in a sharp angle above, over which the enamel folds in a rather deep belt well defined from the basal portion, which inclines slightly outward to the thin inferior edge; inner margin broadly rounded, with a slight concave curvature in passing the coronal depression, the course slightly oblique from the anterior to the posterior angle; postero-lateral border apparently somewhat rapidly converging towards the outer extremity, showing the usual narrow enamel fold along the upper edge, but oftener mutilated from abrasion. Coronal surface occupied by a rather wide, shallow depression, the moderately upraised posterior wing presenting a relatively wide transverse diameter, on the opposite side rising into the gently arched or laterally convex prominence along the antero-lateral border. Triturating surface in almost every case exhibiting indications of excessive wear, in which even the punctate structure is obscure; along the inner margin, however, the teeth often preserve the smooth, dense, polished enamel coating, but in the middle portion of the crown, where the punctæ are best seen, they show only obscure indications of transverse disposition in more or less irregular parallel rows. Length of a medium-size tooth at antero-lateral border about 9 mm; breadth across inner margin nearly 6 mm.

The above description is based upon a few imperfect specimens, which are supposed to represent the posterior teeth of the upper jaw. In general outline and coronal contour they conform to the characteristics of the genus. As already remarked, the punctæ of the triturating surface show an indistinct disposition in transverse rows, in which respect the teeth differ most from typical species of the genus, though to not much greater extent than does the St. Louis species, *Xystrodus imitatus*. It differs, however, from either the St. Louis or Chester species, *X. verus*, in the relatively greater breadth of the inner margin and consequent greater transverse expansion of the posterior alation. From the Upper Burlington *X. simplex* it is distinguished by the greater lateral breadth and convexity of the anterior coronal prominence.

The collections have thus far afforded no recognizable examples identifiable with the broad posterior teeth of the mandible.

Geological position and localities: Keokuk limestone, Hamilton and Warsaw, Ill., Keokuk and Bentonsport, Iowa.

XYSTRODUS IMITATUS, St. J. and W.

Pl. VIII, Fig. 2.

Maxillary posterior teeth small, triangular or sub-cuneate in outline, gently arched longitudinally. Antero-lateral border slightly curved sigmoidally, forming above a sharp angle with the coronal prominence, a narrow enamel belt folding over the upper edge, distinctly defined from the basal portion, which is nearly vertical or projecting slightly outward, terminating in the attenuated inferior edge, which apparently extends nearly the entire length of this side of the tooth; inner margin sharply rounded from the anterior angle with a slight concavity in its course to the slightly produced posterior angle, and forming nearly a right-angle with the antero-lateral border; postero-lateral border gradually diverging from the outer extremity at an angle of about 30 with opposite border, very gently curved, the upper edge enveloped in a narrow fold of the coronal enamel, occupying about half the vertical height of the border. Coronal surface slightly convex in the inner unworn portion of the principal prominence, with a moderately steep slope into the median depression, from which the surface more gently rises into the border of the narrow alate expansion. Surface structure minutely and densely punctate; in the less abraded areas, especially toward the inner margin, the punctæ are arranged in more or less regular parallel transverse lines, conforming in direction to the course of the inner margin. This latter feature, however, is seldom observed to extend over any considerable area of the coronal region, which oftener shows the ordinary punctate structure with only faint traces of the transverse striation alluded to. Length of a medium-size tooth along the antero-lateral border, 10 mm.; breadth at inner margin, 4.5 mm.; elevation of antero-lateral border, 1.5 mm.

The collections afford but few examples of the present species, amongst which occur no examples of the broad alate form attributable to the terminal form of the mandible. Compared with the Chester species, *Xystrodus verus*, it is distinguished by the proportionately greater breadth, generally smaller size, and the less prevalent and distinct transverse disposition of the punctæ of the coronal surface. In proportions and general outline, the species bears striking resemblance to the corresponding form of *X. striatus*, Agass., of the Mountain limestone, Armagh, but it differs in being smaller and in the less marked transverse striation.

Geological position and localities: St. Louis formation; St. Louis (Missouri); Alton, and Monroe county (Illinois), and Pella (Iowa).

XYSTRODUS VERUS, ST. J. AND W.

Pl. VIII, Fig. 6, 7.

Maxillary posterior teeth cuneiform, moderately arched from within outward. Antero-lateral border with slight sigmoidal curvature, abruptly beveled from the coronal angulation, which is obtuse in the region of the inner margin and more acute toward the outer extremity, probably in consequence of the wearing down of the triturating surface, articular border, comprising three-fourths the extent of this side, the upper portion enveloped in the well-defined enamel fold, basal border terminating inferiorly in the thin compressed rim; inner margin broadly rounded at the base of the coronal prominence and gently deflected backward to the posterior angle of the moderately produced alation; postero-lateral border slightly curved, very gradually converging toward outer extremity, coronal enamel forming a narrow fold, inbeveled and well defined from the abrupt downward and slightly outward projecting basal portion. Coronal surface occupied by a broad anterior prominence, slightly arched transversely- generally, however, so worn down over the outer half as to present the appearance of a gradual slope, descending into the shallow median depression, which is bordered on the opposite side by the narrow wing-expansion. A mature tooth measures in length along the anterior lateral border 18 mm.; breadth across inner margin, 9 mm.; greatest depth of antero-lateral border, 2 mm.

Mandibular posterior teeth triangular in outline, rather strongly arched and inrolled at the outer extremity; antero-lateral border steeply beveled from the prominent angulation of the coronal border, a very narrow belt of enamel enveloping the upper edge, beneath which the deep basal belt is more or less distinctly fluted in the direction of inrollment, and terminating inferiorly in the relatively short, attenuated edge, which constitutes about half the extent of this side of the tooth; inner margin forming nearly a right angle with the anterior border, which it joins in a rounded angle, slightly curved sigmoidally in passing to the produced posterior angle of the alate expansion, in breadth about equal to the length of the anterior border of the tooth; postero-lateral border rapidly converging toward the outer extremity at an angle of 50° with the anterior border of the crown, or about 60 with the inferior edge of the base of that side, slightly arched and bounded along the upper edge by the narrow enamel fold, the nearly vertical, slightly channeled basal border posteriorly expanding beyond the coronal limits and produced into a spur-like process forming the extreme angle of the postero alation. The median portion of the crown presents a broad depression, defined on the one hand by the abrupt declivity descending from the elevated angular ridge of the anterior prominence, and on the other by the more gentle acclivity rising to the postero-lateral border of the broadly expanded wing, presenting, as in the previously described form, extreme simplicity in coronal contour. Length along the anterior border of the crown of a large example, 16 mm.; greatest depth of the antero-lateral slope, 5.5 mm.; breadth at the inner margin, 13 mm.

The surface structure of both of the forms described above is essentially identical. The punctæ exhibit in a marked degree the transverse arrangement in more or less regularly parallel lines coinciding with the curvature of the inner margin. This feature is especially noticeable in the region of the coronal depression and the less exposed inner portion of the crown, where, in specimens which have undergone comparatively slight abrasion from trituration, the surface presents a beautifully sculptured appearance from the slightly wavy, coalescing and bifurcating sharp transverse rugæ. The linear parallel disposition of the punctæ may be detected even in much worn surfaces, though, as might be expected, it is here less apparent; and toward the outer extremity, in excessively worn teeth, the surface structure does not differ from that usually met with in the Cochliodonts.

The teeth above attributed to the posterior position on the maxillary are comparable to *Xystrodus striatus*, Agass., from which they are chiefly recognizable by the proportionately narrower outline and perceptibly less expanded alation. The opposed teeth, as herein interpreted, are also intimately allied to a form associated with *X. striatus*, of which the collections of Lord Enniskillen at Florence Court contain numerous representatives. The latter form, with the original *X. striatus*, presents exactly the same association of forms which we have attempted to ascribe to the more prominent dental elements of this genus, as represented in the present species. The Chester tooth, however, differs from the extremely alate examples from Armagh in its great length as compared with the inner transverse diameter, or in directly opposite character to the distinguishing features noted in connection with the maxillary teeth.

Geological position and localities: Chester limestone; Chester, and Monroe county, Ill.

XYSTRODUS BELLULUS, St. J. and W.

Pl. VIII. Fig. 3.

The form here indicated is represented by a small tooth, somewhat imperfect at the apical extremity and along the oblique border and the inner margin, pertaining to the left ramus of the maxillary. Very gently arched longitudinally, narrow wedge-shaped in outline and very gradually tapering, crown broadly arched laterally, an obscure angulation in the median depression defining the anterior coronal prominence from the narrow, slightly upraised alate expansion along the oblique border; along the straight or antero-lateral border the crown is rounded and then sharply inbeveled from the distinct angulation, the narrow enamel fold limited by a slight furrow, beneath which the basal rim is gently produced outward and downward, terminating in a thin, rounded edge. The inferior surface of the tooth is smooth, approximately conforming in contour to that of the crown. The coronal surface is beautifully marked by minute punctæ, having individually the appearance of a minute central cone surrounded by a slightly raised rim, and collectively arranged in very regular, seldom bifurcating or implanted transverse grooves, separated by angular carinæ which appear to form one side of the rims of the medullary tubes. The illustrations convey an accurate idea of the size and relative proportions of the form indicated.

Apparently possessing unmistakable generic relations with *Xystrodus*, the species above indicated differs from the Chester species, *X. verus*, in the details of contour of the articular area of the antero-lateral, and the proportionally greater breadth of the coronal ridge. The unique example described was discovered by Mr. Wm. Gurley, in the shales immediately overlying Coal No. 7, Lower Coal Measures of the Illinois general section at Danville.

GENUS SANDALODUS, N. and W.

SANDALODUS COMPLANATUS, (N. and W. sp.)

Pl. XII, Fig. 1–4.

Deltodus complanatus, NEWBERRY and WORTHEN, 1866, Ill. Geol. Surv., II, p. 98, Pl. IX, f. 4.
Trigonodus major, NEWBERRY and WORTHEN, 1866, ib. II, p. 112, Pl. XI, f. 8, 9.

The forms originally noticed under the above cited names constitute a characteristic group or species of *Sandalodus*, as much so indeed as does the type of the genus *S. lævissimus*, N. and W. The illustrations of this species which are now introduced suffice to show the generic relationship and the probable specific identity of the two forms alluded to in the above synonymy. Both of the above cited descriptions apply to what we regard as probably the posterior form of the mandible, that referred to under the term *Deltodus complanatus* representing a crushed and distorted depressed tooth, examples of which are of more frequent occurrence in the collections than are those corresponding with the extremely convex examples which afford the type of *Trigonodus major*. While these somewhat pronounced varieties seem to be quite distinct, viewed in the extreme examples, a series of teeth like that before us leads to the conviction of their specific identity.

Besides the teeth referred to the mandibular posterior form, the collections also contain a few examples exactly corresponding to the form which we have referred to the opposed position upon the upper jaw. The latter is distinguished by its elongate subspatulate shape, narrow lateral diameter and narrow alation, less rapidly converging lateral borders and more oblique direction of the posterior portion of the inner margin, relatively greater extent of the articular edge of the antero-lateral border, (both borders being much as in the same form of the representative Keokuk species, *S. lævissimus*,) and the more uniform coronal contour, which does not present to the same extent the strongly developed ridges characteristic of the opposed mandibular teeth. In all, as also in the teeth supposed to represent the mandibular median form, the coronal punctation is essentially the same, being relatively fine, closely set, and showing a tendency to elongation in the longitudinal direction of the tooth, although very variable in this respect according to the condition of preservation of the coronal surface.

Mandibular median teeth distinguished by their triangular outline, rather strongly arched from within outward and strongly inrolled at the outer extremity. Postero-lateral border nearly straight, defined above by the rounded enamel fold, basal portion channeled and beveled inferiorly to an obtuse edge; antero-lateral border very oblique, rapidly converging from the subacute inner angle to point of inrollment forming an angle of 40° to 50° with the opposite side, basal portion beneath the enamel fold somewhat channeled and beveled, merging into the thickened edge that defines this side of the tooth; inner margin making nearly a right angle with the postero-lateral border, gently arched and somewhat more sharply rounded near the posterior angle, worn specimens inbeveled inferiorly. Crown transversely nearly plane, slightly arched near the postero-lateral border into the low, obscurely defined coronal prominence; enamel surface near inner margin marked by more or less distinct lines of growth parallel with the inner margin, also faint longitudinal plicæ; worn surface exhibiting the usual minute, closely arranged punctation characteristic of the associated forms of the species. Inferior surface moderately excavated, smooth, conforming in a general way with the contour of the coronal region. A small individual measures in postero-lateral border across the inner margin 10.5 mm.; length along transverse diameter to point of inrollment 6.5 mm. A large-sized tooth is respectively29 mm. and 21 mm. in breadth and length.

Compared with the corresponding form of *S. lævissimus*, of the Keokuk limestone, the mandibular median teeth of the present species are distinguished by their less oblique antero-lateral border and spirally inrolled outer extremity, and smoother coronal surface.

Geological position and localities: Upper Burlington fish-bed; Burlington, Pleasant Grove, Augusta, Buffington creek, Louisa county, (Iowa); Honey creek, Henderson county, (Ill.) The mandibular median teeth especially alluded to above are amongst the beautiful collections from the Buffington creek locality, belonging to Mr. Springer.

SANDALODUS LÆVISSIMUS, N. and W.

Pl. XII, Fig. 8, 9.

Sandalodus lævissimus NEWBERRY and WORTHEN, 1866, Ill. Geol. Surv., II, p. 104, Pl. 10, f. 6, 7, 8.

Sandalodus grandis, NEWBERRY and WORTHEN, ib., II, p 105, Pl. 10, f. 9.

Deltodus grandis, NEWBERRY and WORTHEN, ib., II, p. 101, Pl. IX, f. 9, 9a.

Cochliodus ? crassus, NEWBERRY and WORTHEN, ib., II, p. 91, Pl. VIII, f. 2, 2a.

Psammodus ? semi-cylindricus, NEWBERRY and WORTHEN, ib., II, p. 109, Pl. XI, f. 4, 4a.

Psammodus ? rhomboideus, NEWBERRY and WORTHEN, ib., II, p. 110, Pl. XI, f. 6, 6a.

Mandibular median (?) teeth attaining large size, triangular in outline, strongly arched longitudinally with strong spiral inrollment of outer extremity, lateral borders diverging at an angle of about 50°. Postero-lateral border making an angle of about 30° with the inner margin, very gently curved in its course, coronal enamel forming a narrow fold strongly inbeveled to the channeled basal portion, which is rounded below into the inferior surface of the tooth; antero-lateral border considerably shorter and slightly concave in its course, thick articular edge not shown; inner margin very gently and regularly arched between the subacute anterior and posterior angles, inbeveled below.

Coronal region presenting a uniform plane surface transversely, with a slight convexity near to and parallel with the postero-lateral border, interrupted toward inner margin by irregularly disposed transverse undulations, or lines of growth, and faint longitudinal lines, sometimes appearing as narrow impressed sulci. Surface punctation minute and crowded, along the inner margin concealed beneath the dense enamel layer. The punctate structure bears closest agreement with that observed in the large posterior forms of *Sandalodus lævissimus*. A large-size tooth measures across the inner margin 50 mm.; length along postero-lateral border to point of inrollment, 47 mm.; ditto, along the antero-lateral border, about 30 mm.

Only three examples of the aboved escribed form occur in the collections, and of these only one displays the entire outline and general coronal contour. The latter example was discovered by Mr. L. A. Cox, in the rock excavations for the government canal around the Keokuk rapids on the Mississippi, and to whom we also owe the opportunity to examine additional material illustrating the dentition of this extraordinary species. We have little doubt as to the specific relations of the above described form, and from its peculiar outline and coronal contour, and the strong spirally inrolled extremity (which makes a complete revolution, then becomes involved in the vaso-dentine, forming a solid mass except for the minutest perforation intercommunicating with either border through its center), we are led to identify it with the mandibular median form of this genus. The specimen affording the above measurements doubtless belonged to a mature fish; the middle portion of the crown, indeed, is excessively worn, affording a striking illustration of the severe usage to which the teeth were subjected during life.

It is our belief that the form originally described under the name *Deltodus grandis*, N. and W., is specifically identical with *Sandalodus lævissimus*, N. and W., which latter name was applied to the long teeth which we presume to have held the posterior place upon the upper jaw, the former form occupying the opposed position upon the mandible. The meagre data might not be deemed as affording sufficient grounds for the limitation of the three above-mentioned forms; but the facts themselves, though few, seem to us to offer something more than a mere suggestion of such a relationship. The names *Sandalodus grandis*, N. and W., *Cochliodus ? crassus*, N. and W., *Psammodus semi-cylindricus*, N. and W., and *Psammodus ? rhomboideus*, N. and W., were applied to abnormally worn and otherwise imperfect examples of the maxillary posterior form of this species.

Geological position and localities: Keokuk limestone; Keokuk and Bentonsport, (Iowa,) Hamilton, and Warsaw, (Ill.,) Boonville, (Mo.).

SANDALODUS, sp.?

Pl. XII, Fig. 5, 6.

The Warsaw limestone has thus far afforded very meagre and imperfectly preserved material referable to the genus *Sandalodus*. The Warsaw horizon at the mouth of the Piasa, above Alton, has afforded Mr. Van Horne three individuals, one of which is doubtful, the others representing the forms identified with the posterior teeth of the upper and lower jaws. There are also a couple of similar specimens from the same horizon, one from Monroe county and the other was found by Master Willis Worthen at Golden Bluffs, near Warsaw, in this State. From Indiana localities, probably on equivalent strata, we have seen similar teeth, but these are not now accessible to us for critical comparison.

With a single exception, all of the above mentioned specimens are too imperfect to allow of satisfactory definition and comparison with the species known from other formations, hence we hesitate to undertake their discrimination from allied species which they closely resemble, occurring in earlier and later formations. The small immature individuals of *Sandalodus lævissimus*, of the Keokuk limestone, offer in a general way many features in common with their Warsaw representatives; while the Upper Burlington species, *S. complanatus*, especially the excessively arched examples of the mandibular posterior form, strikingly resemble certain individuals occurring in the Warsaw beds. On the other hand, the latter deposits afford specimens of the same form which might readily be identified with that belonging to *S. spatulatus* of the succeeding St. Louis formation. We are well aware how deceptive are the characters afforded by imperfect materials in this group of fossil teeth, especially when they are not supplemented by a large number of examples from which a more comprehensive understanding of the specific characteristics may be derived. And so far as relates to the specimens here particularly alluded to, we can only reiterate the facts relating to their resemblances, leaving those that may be regarded as peculiar and indicating specific distinctness for future amplification and demonstration.

Geological position and localities: Warsaw limestone, Warsaw; Piasa creek above Alton, and Monroe Co., Ill.

SANDALODUS SPATULATUS, N. and W.

Pl. XII, Fig. 7.

Sandalodus spatulatus, NEWBERRY and WORTHEN, 1866, Ill. Geol. Surv., II, p. 103, Pl. X, f. 2.

Deltodus rhomboideus, NEWBERRY and WORTHEN, 1866, ib., II., p. 100, Pl. IX, f. 8.

Sandalodus crassus, NEWBERRY and WORTHEN, 1870, ib., IV, p. 369, Pl. IV, f. 3.

Mandibular median teeth small, trapezoidal in outline, moderately arched in the direction of inrollment, breadth apparently exceeding the length. Postero-lateral border nearly straight, with a slight oblique course outward and forward, enamel fold narrow, basal portion relatively deep, slightly channeled; antero-lateral border converging toward point of inrollment at a moderate angle with the opposite border, the relatively deep basal rim projecting beyond the coronal fold; inner margin gently arched from the rounded posterior angle, with a slight sigmoidal curvature in passing to the subacute anterior angle; as usual the edge is inferiorly beveled. Crown surface very gently and uniformly convex transversely, the enameled inner portion showing transverse imbrications or lines of growth parallel with the inner margin, with the usual delicate rugose appearance, beneath which the tubular structure is discernible, and which in worn surfaces assumes the minute, closely arranged punctate character. Greatest transverse diameter across inner margin, 13 mm.; length along postero-lateral border to point of inrollment, about 8 mm.

The form above described is represented by a solitary specimen, in the collection of Mr. Van Horne. The tooth is in good preservation, save that the outer margin has been entirely worn away, presenting a thick, blunt emarginate edge, the inrolled extremity on the posterior side being much more worn than at the opposite side. The inferior surface of the tooth, however, plainly shows the direction of the oblique inrollment, as indicated by the course of the longitudinal striation. The form agrees in all essential particulars with the homologous teeth noticed in connection with *Sandalodus complanatus*, and *S. lævissimus*; at the same time it also agrees, in the character of the surface punctation and the delicate rugose markings of the enamel layer, with the other forms of the species to which we have referred it. However, in the supposed associate forms we have failed to detect the presence of transverse lines of growth, such as constitute a marked feature in the enamel layer of the present form. The uniform transverse convexity of the coronal region and its outline readily distinguish the present tooth from its congeneric allies.

Referring to the synonymy it will be observed that the form originally described under the name *Deltodus rhomboideus*, N. and W., is transferred to the specific category embracing the form first noticed under the term *Sandalodus spatulatus*, the two forms respectively representing the supposed posterior teeth of the lower and upper jaws of the same species. These forms most intimately agree in the details of coronal structure, while they differ one from the other in outline and coronal contour exactly after the manner noticed in the Keokuk and Burlington species. The tooth subsequently described under the designation *Sandalodus crassus*, N. and W., from the same formation, is identical with the former described form, the original account of *S. spatulatus* being founded upon an imperfect, excessively worn tooth. The collection of Mr. Van Horne contains a splendid suite of the latter forms, in all stages of growth and conditions of preservation, permitting of the most satisfactory study of their normal peculiarities and variations, so far as this may be made from detached and scattered teeth.

Geological position and localities: St. Louis limestone; Alton, and Monroe county, Ill., St. Louis, Mo.

GENUS ORTHOPLEURODUS,[1] St. J. and W.

Posterior teeth of the upper jaw subspatulate in general outline; postero-lateral border straight or nearly so, and probably gently curved downward and inward at the outer extremity and gently arched in the same direction, terminating posteriorly in an acute angle or spur, whence the inner margin, which is greatly thickened or massive, is broadly rounded into and merging with the thin antero-lateral border towards the extremity. Coronal surface occupied by a prominent principal fold or ridge rising nearest the straight border, and flanked on the anterior slope by an obscure secondary ridge; the punctate enamel forms a distinct narrow fold along the thickened straight border, where it is distinctly defined from the basal portion by a slight groove.

Teeth supposed to have occupied a similar position on the mandibles, distinguished by their trigonal outline, somewhat strong and spiral inrollment of the extremity, toward which the antero and postero-lateral borders regularly converge, inner margin more or less obliquely rounded and sigmoidally curved from front towards the posterior angle. Coronal surface presenting a more or less well-defined plane anterior fold, abruptly broken down on that side, where the coronal enamel forms a wide belt sharply defined from the deep basal rim, and limited behind by the more or less deep longitudinal depression from which rises the alate posterior lobe, which is limited exteriorly by a narrow fold of enamel separating the crown from the basal portion of the tooth.

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[1] (*Orthos*, straight; *pleuron*, side; *odous*, tooth; in allusion to the straight postero-lateral border of the maxillary posterior tooth.)

Mandibular median or second teeth characterized by their triangular outline, rather strong inrollment of the outer extremity, straight postero-lateral border which is similarly enameled to the antero-lateral border of last above described posterior dental plates, antero-lateral border rapidly and irregularly converging from the subacute angle of the broad, slightly arched inner margin. Coronal surface forming a broad, low arch, or nearly plane transversely.

Although in every case detached and separated from their natural position upon the jaws, there is strong inferential evidence of the dental elements described above having constituted parts of the dentition of one and the same fish, as will appear more at length under the head of specific descriptions. The genus as here constituted does some violence to the interpretation of the affinities of the teeth attributed by authors to other genera, but the facts are believed to justify no other conclusion, while in the typical species, at least, there can hardly exist a doubt as to the specific identity of the widely dissimilarly shaped teeth alluded to in the foregoing generic diagnosis.

The genus as now understood includes, besides the American forms hereinafter described, possibly a form of teeth from the Carboniferous limestone of Bristol (England), which has been referred to *Tomodus*, Agass. All the specimens of maxillary teeth are mutilated by having their exceedingly thin anterior portion broken away; and this fact naturally suggests the possible occurrence of corresponding dental plates in European collections—however, in so fragmentary a state as not to have attracted attention to their probable relationship with the more robust mandibular teeth.

Compared with *Sandalodus*, N. and W., the following distinguishing features are especially noticeable: The posterior form of the mandible is abruptly broken down in a prominent mural face along the antero-lateral border, which is enveloped in a widish belt of the coronal enamel, and the anterior position of the transversely, nearly plane, well-defined coronal prominence, in all which there is striking contrast with the very restricted antero-lateral articular border of typical homologues of *Sandalodus*. In the posterior teeth of the upper jaw, the coronal prominence, instead of being situated forward of the median line, as in *Sandalodus*, rises close along the postero-lateral border, the wide coronal declivity being transferred to the opposite side of the tooth. The median teeth of the mandible, representatives of which belonging to either generic group are exceedingly rare, present essentially the same characteristics so far as the meagre materials at the present time in hands permit of being determined.

The earliest representatives of the genus occurring in American rocks were discovered by Mr. Springer in Lower Carboniferous strata, probably of Chester age, of New Mexico; the typical representative species, *Orthopleurodus carbonarius*, belongs to the Upper Carboniferous, the upper division of which has afforded the majority of specimens thus far, although apparently the same species is not unfrequently met with in deposits near the base of the Coal Measures.

ORTHOPLEURODUS CARBONARIUS, (N. and W. sp.) pars.

Pl. XIII, Fig. 6, 8.

Sandalodus carbonarius, NEWBERRY and WORTHEN, 1866, Ill. Geol. Surv., II, p. 104, pl. X f. 4, 5.

Deltodus angularis, NEWBERRY and WORTHEN, 1866, Ill. Geol. Surv., II, p. 97, Pl. IX, f. 1

A singularly interesting group of teeth discovered by Mr. L. A. Fuller in the shales over Coal No. 5 of the Illinois General Section of Coal Measure strata, at Bloomington, leaves little room for doubt respecting the specific identity of the above cited forms, and with which is associated a third form probably holding a position immediately in advance of the posterior tooth of the mandibles, that originally described under the name *Deltodus angularis*. This "second" or median tooth of the mandible is distinguished by its triangular outline, straight postero-lateral border corresponding in coädaptation with the articular border of the above mentioned posterior tooth, and the uniform depressed coronal contour. A similar tooth has been obtained from the Upper Coal-Measure strata near Topeka, Kansas, where individuals of the long posterior teeth of the upper jaw (*Sandalodus carbonarius*) have also been found; and only recently Professor Worthen has brought from the Upper Coal strata at LaSalle, representatives of all three forms. The generic diagnosis, founded on the typical specific forms belonging to the present species, sufficiently describes the individual characteristics of the various dental elements here ascribed to it.

The group of teeth discovered by Mr. Fuller, which bear every appearnce of having belonged to one and the same individual, present the following proportionate measurements: Maxillary posterior tooth, greatest preserved length along the straight border 18 mm.; greatest breadth 7 mm.; breadth at broken extremity 6 mm. Posterior tooth of mandible, greatest length from posterior extremity to outer inrolled extremity 14 mm.; greatest breadth between angles of inner margin 9.5 mm.; breadth of coronal prominence at inner margin 5 mm.; length along antero-lateral border 11 mm. Mandibular median tooth, length along posterior articular border 8 mm., breadth along inner margin 6.5 mm.

The long posterior teeth of the mandible, which in well-preserved examples show the coronal ridge defined on either side by a slight impressed angulation, owing to the extreme thinness of the outer portion are invariably mutilated by having the outer extremity broken away. This attenuation is probably due in part, at least, to the excessive wear this part of the coronal surface has been subjected to while in use, and the vicissitudes to which they have been exposed subsequent to their disengagement from the maxillary supports has resulted in disfiguring this part of the teeth so that the form of the extreme antero-lateral border and outer extremity can only be conjectured. However, it probably partook of the general characteristics of the corresponding tooth of *Stenopterodus* and *Deltoptychius* in truncation and definition of coronal and basal regions. The far more uniformly massive posterior teeth of the mandible, however, are often found quite entire. The position and consequent severe usage suffered by the median teeth of the mandible by which they have been defaced, as also their extremely simple form, may have led to their being overlooked in many instances.

Geological position and localities: The stratigraphical distribution of the above species, as it is at present understood, is known to extend from the lower part of the Lower Coal Measures, well up into the Upper division; the vertical range in Kansas is known to include above 1,500 feet of exclusively Upper Coal Measure strata; LaSalle, Springfield, Carlinville, Staunton, Belleville, Bloomington, Danville, also, localities in Fulton and Vermilion counties, Illinois; Posey county, Indiana; several localities in the Upper Coal Measures of Iowa, Nebraska, Kansas and Missouri.

ORTHOPLEURODUS CONVEXUS, St. J. and W.

Pl. XIII. Fig. 4, 5.

Posterior teeth of mandible agreeing closely in outline with the corresponding form of *Orthopleurodus carbonarius*, moderately arched from within outwards and revolute, antero-lateral border moderately curved sigmoidally, and occupied by a rather deep enamel belt beneath the sharp, anterior coronal angulation; inner margin broadly and obliquely rounded, with slight sigmoidal outline extending into the posterior alation, which latter is usually broken away. Anterior coronal lobe occupying half or more the breadth of the tooth, gently arched transversely, conspicuously so toward the inner margin, merging into the postero-lateral depression, from which it is defined by the rounded angulation of that side. Surface uniformly and minutely punctate. Length of a medium size tooth along antero-lateral border, 19 mm.; breadth across inner margin, about 14 mm.

Maxillary posterior tooth subspatulate in outline, broadly rounded at inner margin, postero-lateral border slightly concave, gently arched from within outward, extremity not known. Crown surface considerably arched transversely over the principal prominence in the vicinity of the inner margin, where the tooth attains comparatively thick, massive proportions, the ridge anteriorly rapidly diminishing in prominence. Surface punctation minute and uniform. Length of a tooth below medium size along straight border, probably at least 15 mm.; breadth, about 9 mm.

The above descriptions are founded upon a single example of each form, respectively, discovered by Prof. J. J. STEPHENSON. Both specimens are in imperfect condition, but such parts as remain present certain peculiarities which seem to justify their reference to a distinct species. Compared with the species prevalent in the Coal Measures of the western States, *Orthopleurodus carbonarius*, the mandibular posterior tooth differs in the marked transverse convexity of the principal lobe along the straight side, instead of being flat, as in that form: the opposed teeth of the upper jaw are very like, in both the western and eastern forms, -the latter, perhaps, being distinguished by its more massive proportions in the region of the inner margin. A larger suite of material from the Allegheny region may show the above distinctive features to be of subordinate importance, marking mere individual variation, but in a direction not apparent in any of the western specimens.

Geological position and locality: From strata above Mahoning sandstone, Coal Measures; near Morgantown, West Virginia.

ORTHOPLEURODUS NOVO MEXICANUS, St. J. and W.

Pl. XIII, Fig. 1-3.

Teeth below medium size, represented by forms occupying the posterior position on the lower and upper jaws.

Mandibular posterior teeth trigonal in outline, moderately arched in the direction of inrollment. Antero-lateral border slightly curved sigmoidally, enamel belt abrupt and well defined from the downward and slightly outward produced basal-rim; postero-lateral border making an angle of about 55° with the opposite side; inner margin slightly obliquely produced backward from the anterior angle and gently curved sigmoidally, worn specimen inbeveled inferiorly. Coronal prominence usually well defined, rather widely expanded toward the inner margin, posterior slope merging into the regularly transversely concave posterior depression, from which the alate expansion steeply rises into the prominent postero-lateral border. Surface punctation exceedingly minute and widely spaced. Breadth of a large specimen between the angles of the inner margin 13.5 mm.; length along antero-lateral border to point of inrollment about 12 mm.

Posterior teeth of upper jaw subspatulate in outline; antero-lateral border unknown, that extremity of the teeth being extremely attenuated and in consequence mutilated; postero-lateral border exhibiting the characteristic straight outline, basal border slightly channeled, and probably continued into a spur-point at the posterior angle; inner margin broadly arched backward round the coronal prominence and thence more gently curved toward the broken anterior angle. Coronal ridge prominent, rounded along the crest which culminates close upon the postero-lateral border to which the surface steeply descends, the broad anterior slope slightly depressed before reaching the margin of the tooth, the ridge more or less rapidly declining immediately behind the greatest prominence. Punctate structure the same as observed in the mandibular teeth. An ordinary size specimen measures along the postero-lateral border about 15 mm., greatest breadth of tooth at right angles to the straight border 7 mm.

The present species is determined from a few specimens of the maxillary posterior form and a single example of the mandibular posterior tooth, which were discovered by Mr. Springer, in the fish-bed stratum near the base of the Carboniferous series at Santa Fé, New Mexico. The state of preservation of the specimens, although not perfect, is sufficient to afford the basis of comparison with the allied species *Orthopleurodus carbonarius*, occurring in the Coal Measures of the Mississippi Valley. While the present species is smaller in size, the mandibular posterior teeth differ from the latter in their proportionately greater breadth as compared with the length along the antero-lateral border: the maxillary posterior teeth may be distinguished by the apparently less oblique course of the coronal ridge, while the surface punctation is much the same in both species, the punctæ, perhaps, more widely spaced in the New Mexican teeth. Its resemblances with the above species is more intimate than with *Orthopleurodus convexus*, although there is a marked similarity in the maxillary posterior forms, as indicated by the imperfectly worn examples.

Geological position and locality: From the fish-bed layer near the base of the Carboniferous series, associated with other Lower Carboniferous fish-remains; near Santa Fé, New Mexico.

PSAMMODONTIDÆ, L. de Koninck.

GENUS PSAMMODUS, Agassiz.

Psammodus, AGASSIZ, 1843, Poissons Fossiles, tome III, p. 110.

Teeth quadrilateral or trapezoidal in general outline, variable, usually thick and massive. The coronal region presents a more or less plane surface, according to the position the form occupied upon the jaws, always arched, generally moderately, in the longitudinal direction or from behind forward, transversely concave (maxillary teeth), or more or less convex (mandibular teeth), sometimes raised into a low ridge along the exterior lateral border, also along the articular inner border, or showing a more or less wide convexity in the latter region, and sometimes presenting a more or less well defined transverse prominence in mature maxillary form. The marginal limits of the crown are well defined, rounded along the exterior of lateral border and usually inbeveled, and almost always making an angulation at the articular inner border and along the anterior and posterior margins, the enamel extending well down and more or less distinctly defined from the coarse vermicularly pitted basis, which constitutes the greater part of the height of the tooth. In front and behind, the basal wall is nearly exactly vertical to the plane of the coronal surface and moderately channeled or concave; the inner articular face is also vertical and slightly excavated, presenting generally at one or the other extremity an obliquely truncated articular facet for co-adaptation with the contiguous tooth of the opposite series, the extent and obliquity of the truncation varying greatly according to the species; the exterior lateral border, in typical forms, shows an expansion of the basal portion beyond the coronal limits, increasing in breadth and terminating in a more or less produced spur at the postero-outer angle of the tooth. The coronal surface exhibits under an ordinary lens a distinct vertical prismatic structure, each of the vertical columns enclosing a medullary tube the appearance of which at the surface produces the exceedingly minute punctation usually observed in these teeth; the exceedingly elegant vermiculose rugosity exhibited in the less worn surfaces of certain species is produced by the wrinkling of the enamel or external layer, and which apparently has no other relation to the medullary tubes than to rudely define them in irregular and transverse or longitudinal rows, the punctæ rarely confluent, and the rugose appearance becoming obsolete or more or less obscured over the more exposed parts of the triturating surface. The impression also prevails that the tendency to rugosity of the coronal surface increases with age, since this appearance so far as observed seems to be most prevalent and conspicuous in large individuals belonging to the series which have received several accessions, the innermost individuals of which have suffered little from the abrading effects of trituration while in use; but it is not an essential character, as some species evidently always remained quite smooth in their coronal areas. The inferior surface is plane, in a general way conforming to that of the crown, and even possessing distinctive characteristics as applied to species; it shows in the perfect state a rather dense thin layer, perhaps in degree rather than structually differing from the more cellulose middle layer composing the bulk of the base, and usually marked by more or less distinct longitudinal grooves, or smooth, and faintly keeled nearest the inner articular border.

In drawing up the foregoing diagnostic account of *Psammodus*, the authors have been actuated by the desire to place before the student of palæichthyology such data as they themselves possessed relating to the genus, and which they owe largely to the kind offices of their colaborators. It will have been observed that the genus embraces a variety of *forms*, which, while their generic identity is unquestioned, offer so diverse appearances as, in the absence of other than detached and fragmentary remains, to greatly complicate the determination of the relative position the forms occupied upon the jaws. Their congeneric identity is proven by identity of outline and contour and superficial structure common alike to each and all of the forms, and these latter resolve themselves into certain well-defined groups, so that specific distinctions may be recognized in unique examples pertaining to one or the other form. But in the attempt to associate these forms under definite, specific combinations, the observer is necessarily compelled to rely, to some extent at least, on other than superficial resemblances, as, for example, the association of the individuals in the horizons whence they were derived. The process is often further complicated by the accidents of collecting, for it not unfrequently happens that a series of teeth from a locality consists not of a single form merely, but of individuals pertaining to the same side in relation to their position upon the jaws. However, fortunately, now and then appears a specimen which seems to set at rest whatever doubts may have been entertained as to the actual state of things, and in a few of the species the collections are rich in data going to establish a more precise and comprehensive understanding of the species themselves and the family and ordinal relations of the genus.

So far as has come to the notice of the writers, the genus *Psammodus* has been classed by authors with the Cestracionts; Dr. L. de Koninck, however, recognizing their distinct family character, for which he proposed the term Psammodontidæ.[*] As early as 1843, Captain Jones, in a communication in reference to his acquisitions of fish remains from the mountain limestone localities in the vicinity of Armagh, says: "There are good specimens of one more tooth, somewhat allied to *Psammodus*, yet having a distinct character, which will connect it with the Myliobates;"[†] and to whom should be credited thus early the recognition of the affinities of the Psammodonts.

The examination of a considerable suite of the teeth of *Psammodus* must convince one of their having originally occupied a serial position upon the jaws, stretching across from side to side, in the manner exemplified by the *Myliobates* of Tertiary and existing seas. Indeed, Dr. de Koninck alludes, loc. c., to a series of three teeth of the species *P. porosus*, found by Mr. Neilson in the mountain limestone deposits near Glasgow (N. B.), which still retain their relative position to one another, and with which the distinguished palæontologist reconstructs the dental armament of the jaw. But perhaps the most complete and satisfactory information to be derived from isolated detached teeth is that secured by Mr. Springer of the species bearing his name, from the Upper Burlington limestone of our Lower Carboniferous series. The latter are so well preserved as to furnish many and highly desirable details without which still some uncertainty might intervene to a satisfactory conclusion on the chief points relating to the disposition of the teeth upon the jaws. These show conclusively that the teeth were arranged in at least double rows, not exactly opposite, but the tooth of one or other row in advance of its mate, the articular border showing obliquely truncated facets at one or other angle by which it is coadapted to the articular faces of the two contiguous teeth of the opposite parallel row, thus producing an asymmetrical alternating arrangement only less symmetrical than obtains in the modern *Myliobates*. That their real affinities are with the Myliodonts there can be no doubt; but whether they should be regarded as entitled to a specific family rank distinct from their living allies, we do not deem ourselves prepared at the present moment to affirm. As far back as 1862, Professor Agassiz, as is well known to his students who were at that date and subsequently matriculated at Cambridge, had recognized the ordinal relationship of the Psammodi, and besides the typical *Psammodus* he also included the several allied genera of the *Aetobates* type anticipated thus early in the earth's history by the genera *Copodus, Pleurogomphus, Pinnacodus, Labodus, Dimyleus*, etc., which were recognized from mountain limestone species occurring in the British Islands.

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[*] Faune du Calcaire Carbonifère de la Belgique, II, p. 38, 1878.

[†] Report on the Geology of Londonderry, etc. by J. E. Portlock, F. R. S., F. G. S., etc., 1843, p. 462.

Notwithstanding the incompleteness of our materials in certain important particulars, we deem it something more than mere conjecture the assignment of the forms to definite positions upon the jaws. As is well known, the maxillary dentaries of *Myliobates* present a gently longitudinally arched condition so far as relates to the grinding surface of the series of teeth with which the jaw was paved across; and that the mandible presents in comparison a triturating surface strongly rolled in the same direction. The same state of things may readily be appreciated in a suite of examples of *Psammodus*: The nearly plane or longitudinally slightly arched and transversely more or less concave coronal contour of the teeth, may with reason be regarded as having belonged to the upper jaw; and those teeth which exhibit a contour almost the reverse of that just noticed, being perceptibly more strongly arched longitudinally, also transversely convex, with a more rapid convergence of lines projected vertically to the coronal surface downward from either margin, indicate for a series of teeth a more strongly rolled surface area than in the above mentioned form, and corresponding in this essential to the teeth composing the series of the mandible in the Myliodonts. But the collections, both European and American, afford examples of a form which, possessing essentially the outline and contour of the previously mentioned forms, differ from them in their oblong shape, being relatively longer than wide, and the depressed median region and rounded condition of the coronal folds along the lateral borders. All of the examples of the latter form which have come to our notice are further distinguished by the relatively great depth of the basal portion, which, however, in other respects intimately agrees with the associated forms. They plainly held a lateral position, and from the character of the articular border, especially as displayed in mature individuals, they apparently alternated with a row of median symmetrical teeth, of whose remains, however, not a vestige has been detected in the collections accessible to us. In the event of the above inference proving well founded, the latter form would, with its associates, present a dental formula entirely unique and distinct from what obtains in typical *Psammodus*. There is marked diversity amongst the latter, as will be made apparent in the subjoined descriptions of species.

Attention is also directed to certain resemblances existing between the Psammodi and Cochliodonts. As is well known, the teeth of the latter were disposed on distinct rami of the jaws, instead of spanning the jaws from side to side, as is the case with the Psammodonts. But in respect to the outer lateral borders of certain forms of teeth representative of the two families, characteristics are observed which hardly are to be relegated to the category of mere resemblances, and the presence of which suggests interesting homologies between the respective forms belonging to either group. In this way the projection of the basal rim beyond the coronal border in the external border and its prolongation into an acute spur terminating at the posterior extremity, are unquestionably the same in the exterior and posterior terminal forms of either family,—the posterior teeth of Cochliodonts homologically corresponding with the form constituting the exterior rows of teeth in the Psammodonts, even the direction of the obliquity of this side adding stress to the likeness in which the forms of both families share. The succeeding forms of the Cochliodonts find their representatives in the *inner* rows (where such exist) of the Myliodonts, and in those genera of the latter in which the jaws are arched by a single row of dental plates. The condition is such as would be produced were the rami of the Cochliodont jaws drawn out into a transverse position and their dental armature consolidated into single plates stretching from side to side across the symphysis. Indeed, in these early forms a much more intimate relationship exists between the types of these two great orders of Selachians than obtains between their representatives of later geological times.

The genus is strictly of Carboniferous origin and duration, indeed beginning nearly at the dawn of the earlier period and ceasing at its close. The Coal Measures thus far have not yielded a trace of the remains of ***Psammodus***.

[illegible] St. J. and W.

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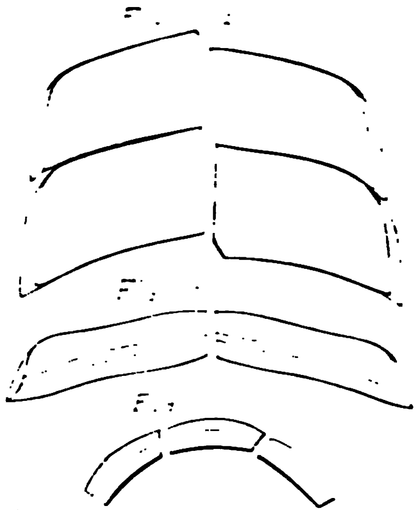

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Mandibular teeth rhomboidal in shape, variable in the proportions of length and breadth; anterior and posterior margins nearly parallel; very gently and irregularly curved forward, the coronal belt occupying less than one-third the vertical height of the tooth, extending deepest in the anterior margin, and in well preserved examples crenulated with vertical plaits, producing an exceedingly beautiful sculptured belt well defined from the deep basal portion by a slight inbeveled band; the basal portion is also marked by irregular vertical rugosities, worn surfaces exposing the coarse osseous structure which extends to the dense, thin inferior layer. The inner border is usually nearly straight and vertical, the enamel belt continuous with that of the margins, though less distinctly sculptured; one or other angle of the border is truncated at a slight angle, presenting an articular facet of variable extent, though not always well defined from the greater articular face. Outer border presenting a more or less rounded angle in front, gently curved and terminating in a more or less produced angle or spur posteriorly; the coronal enamel is well defined and margined posteriorly by a widish expansion of the basal border, which is continued into the posterior spur. Coronal surface very gently and regularly arched longitudinally, the angle of the posterior and anterior margins and inner articular border sharply defined, that along the outer border rounded from the lesser coronal fold of that side, which is sometimes defined by a narrow impressed line, though usually merging into the shallow median depression, from which rises the wider, very slight convexity that occupies the inner portion of the surface. In some specimens the coronal surface shows distinctly the prismatic structure, the minute punctae being less discernible.

The teeth are so variable in relative dimensions that comparative measurements are of little use for other purpose than to show the maxima attained by the species, as indicated by the breadth; thus, the largest perfect example shows a transverse diameter across the posterior margin of 33 mm., the smallest perfect tooth measuring about 16 mm. in breadth.

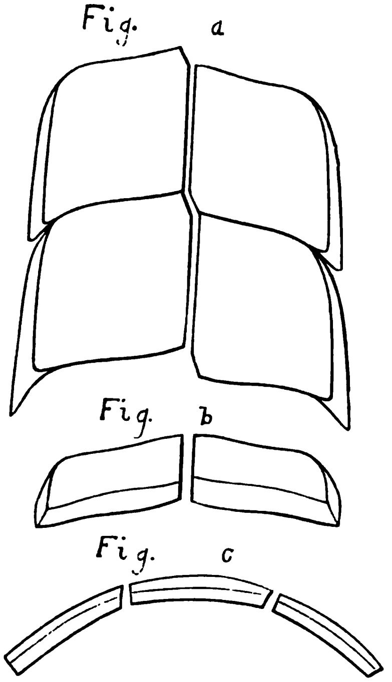


Diagram of maxillary teeth of *Psammodus Springeri.*

a. Maxillary series, triturating surface.

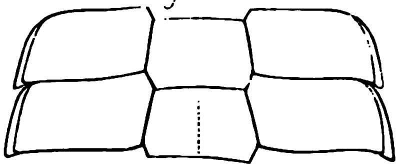
b. Transverse profile of maxillary series.

c. Longitudinal profiles of maxillary series.

A form differing from that above noticed chiefly in the proportionately greater length of the teeth, compared to their breadth, giving them a more lozenge-shaped outline are quite as numerously represented in the collections, and which we suppose to have constituted the armature of the opposite jaw of the same species. Examples of much-worn, mature teeth present an almost regular arch, or curvature, from the inner anterior to the outer posterior spur angle without distinct intermediate angulation at the junction of the exterior border with the anterior margin, and the inner coronal prominence, as also the outer lesser ridge, is reduced to a nearly plane surface transversely. The inner articular border is quite straight, extremely thickened and wedging out towards the exterior border; in every instance of the teeth here admitted, the truncated facet is extremely small, sometimes occurring at one angle, again at the opposite; however, most of the specimens being truncated at the posterior angle. The very gentle longitudinal convexity of the coronal surface of the tooth indicate that the curvature of the series constituted a smaller segment of a circle than was the case with the before-mentioned form; hence the supposition of their maxillary position. In dimensions, as also in surface structure, the form agrees with that previously noticed.

The above noticed forms are about equally represented in numbers in the collections from the Upper Burlington "fish-bed," where they are not uncommon fossils. The truncated articular facets vary somewhat in extent as they do also in position, occurring in one individual at one angle and in another at the opposite angle; and judging from the character of the articular border, it seems most probable that the teeth were ranged in double rows, the individuals of one or the other range slightly in advance of the corresponding teeth of the opposite range, the long articular face and short facet of one tooth joining the same parts of the opposite contiguous tooth. This presumed disposition of the teeth produces the alternating appearance shown in the outline diagrams given in connection with the illustrations of the several sorts of teeth here specifically associated. The individuals of the two forms show precisely the same variability in the truncated angle of the inner articular border, though the asymmetry is much less pronounced in the supposed maxillary form than it is in the shorter form referred to the mandible of the same species. Indeed, it is the absence of symmetry in these teeth that offers one of the strongest contrasts with the living representatives of the family. Yet it should be remembered that the existing Myliodonts are subject to abnormal variations, such as the interpolation of an extra row of lateral dental plates, while the individuals of the several ranges are placed in alternating order. The collections have been ransacked, but without result in revealing the vestige of a symmetrical median dental plate, such an one as would restore to the rows of teeth a perfectly symmetrical arrangement, like that illustrated in the hypothetical diagram annexed, the lateral forms of which will readily be recognized in the illustrations of actual specimens. We can, therefore, only conjecture the possible existence of median teeth similar in shape to the supposed form shown in the diagram, and their absence amongst the score and a half of examples of the lateral forms contained in the collections, would seem to afford slight grounds for the supposition of the existence of intermediate symmetrical teeth in the dental formula of the genus to which the species belongs.

Fig. a



Hypothetical diagram showing median dental plates of *Psam. Springeri* (mandible).

Geological position and localities: Upper Burlington limestone, "fish-bed;" Buffington creek, Louisa county, Pleasant Grove, Augusta, and Burlington, Iowa; Cedar creek, Henderson county, and Quincy, Illinois.

PSAMMODUS TUMIDUS, St. J. and W.

Pl. XIV, Fig. 1-4.

The collections contain several examples representing two forms corresponding with the supposed mandibular and maxillary teeth of the foregoing species, *Psammodus Springeri*, of the same deposits, and which, presenting apparently persistent characters by which they may be distinguished, we are led to provisionally indicate under a distinct specific appellation. Presenting the same general outline, they are distinguished from *P. Springeri* principally by the greater extent of the truncated angle of the inner articular border and the distinct longitudinal rugosities that make a highly wrought ornamental belt usually extending a short distance forward from the posterior margin, both of which characters are common to the two forms. The short, broad mandibular teeth do not differ otherwise to any marked extent from the same form of the above-mentioned species, unless the crown shows a somewhat greater transverse concavity and more strongly arched contour from within outward; however, the prominence along the inner lateral border is somewhat more distinctly defined by longitudinal furrows than is observed in the corresponding teeth of *P. Springeri.* But in respect to the maxillary form, the most striking contrast is noticeable in the latter particular. The inner coronal prominence becomes strongly developed, presenting a distinctly defined lobe, laterally rounded with steep declivity falling to the depressed median area, which in some instances is quite strongly plicated longitudinally in addition to the rugose belt ornamenting the crown surface immediately along the posterior margin; in worn examples the rugose sculpturing is obsolete. In the majority of instances the limit of the inner coronal ridge is defined by a narrow impressed line. The lesser coronal ridge along the exterior lateral border bears intimate resemblance to *P. Springeri,* and the same observation may be applied to the superficial structure of the teeth.

At the outset we were inclined to regard the teeth above referred to as merely variations from the normal condition of *Psammodus Springeri.* Indeed a more extensive suite of material may possibly prove them to be specifically identical. The individuals exhibit precisely the same variableness as regards the position of the truncate angle of the articular border, though, as has been already remarked, the facet is of greater extent; indeed, in some instances occupying nearly half the length of the border.

Geological position and localities: Upper Burlington limestone, chiefly from the main "fish-bed," a single example from the upper fish-bed horizon; Buffington Creek, Pleasant Grove, Augusta, Iowa, and Quincy, Illinois.

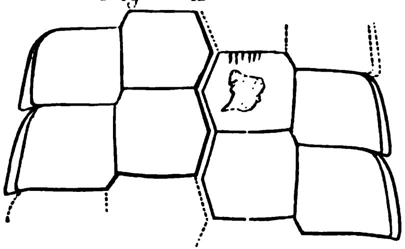
PSAMMODUS TURGIDUS, St. J. and W.

Pl. XV, Fig. 4.

A unique example of the maxillary tooth, derived from the fish-bed of the Burlington-Keokuk "division beds," shows a still wider divergence from *Psammodus Springeri*, and which we have provisionally recognized under the above specific designation. In outline the tooth resembles the same form of *P. Springeri* and *P. tumidus*, its relationship with the latter being most intimate. The inner border is nearly equally divided into two long articular facets separated by an angulation, the truncate facet being at the posterior angle, the coronal belt very deep and well defined from the slightly channeled basal portion. The inner coronal ridge is very prominent, occupying fully half the transverse diameter of the crown, broadly arched in both directions and defined from the median depression by a sharp impressed line; outer lateral border not known. The surface shows a minute punctate structure through the dense enamel layer enveloping the crown; along the posterior margin the surface presents a beautiful rugose appearance from the beaded longitudinal plicæ, which extend some distance from the margin, and the articular border as also the preserved portions of the anterior and posterior margins are similarly ornamented with vertical rugosities. The specimen measures between the angles of the inner border 15.5 mm. probably about the same as the greatest transverse diameter at the posterior margin.

A solitary and somewhat mutilated specimen, obtained by Mr. Springer from the main fish-bed of the upper Burlington limestone, presents exactly the same character of inner articular border that distinguishes the above described tooth. But the coronal prominence of the latter example, although very broad, is comparatively low and merging into the shallow median depression, which was apparently bordered exteriorly by a nearly straight, vertical face similarly marked to the other vertical sides by vertical beaded rugosities. This specimen, if it is correctly deciphered, has a nearly rectangular outline so far as relates to the external border and the anterior and posterior margins, the angulation of the inner border giving the tooth a pentangular figure. Taking into consideration the vertical condition of the straight exterior border, which shows features consonant with an articular face, this tooth certainly suggests a form not hitherto recognized, and which is at the same time a true *Psammodus*. It is possible that the specimen represents one side of a median series of teeth comprising two ranges, the inner articular borders alternating and the exterior borders joining the inner articular borders of teeth of the form of those described under *P. Springeri*, &c.? The specimen is strongly suggestive of such a combination of dental elements, after the fashion sketched in the annexed cut, Fig. a. The specific identity of the "division bed" tooth and that last referred to from the main fish-bed of the Upper Burlington, is only conjecturally inferred. The partially shaded pentagonal plate on the right of the double median series gives a reduced outline of the specimen here referred to.

Fig. a



Hypothetical diagram of *Psammodus turgidus*.

Geological position and locality: Fish-bed of the Upper Burlington-Keokuk division beds; DesMoines Co., Iowa.

PSAMMODUS LOVIANUS, St. J. and W.

Pl. XIV, Fig. 7-9.

Teeth attain medium size. Maxillary form subrhomboidal in outline, rather strongly arched from within outward. The margins gently arched forward and parallel, the anterior margin apparently somewhat strongly inbeveled, though really vertical to the edge of the crown surface, posterior margin showing a belt of enamel extending perhaps one-fourth its depth, and well defined from the slightly excavated base. Inner border making nearly a right-angle with the margins, the truncated posterior angle reaching about one-fourth the distance of the border, and making a rather strongly marked angulation with the anterior portion of the articular face.

The enamel belt also distinctly defined and delicately sculptured in vertical rugosities, traces of which are also detected in the belt of the anterior and posterior margins; outer border gently curved, and very gradually diverging from the rounded anterior angle to the posterior angle, which terminates in a somewhat produced spur, the basal portion projecting prominently beyond the border of the crown, which is limited by a narrow enamel fold. The coronal region presents a remarkably uniform surface, in the main gently depressed transversely without well-defined inner prominence, and rather abruptly upraised along the outer border, which forms the most prominent part of the coronal surface. The worn surface exhibits minute punctation, and the less worn portions show a delicate reticulate structure, produced by the walls of the vertical prisms enclosing the medullary tubes. Greatest diameter across the posterior margin, 53 millimeters; length along the inner margin, about 30 mm.: breadth across anterior margin, 38 mm.; thickness of tooth, about 15 millimetres.

Mandibular form subquadrangular in outline, moderately arched in both directions. Inner border marked by a slight angulation defining the anterior and posterior articular facets which are apparently nearly equal in extent, coronal enamel well defined along the deep, slightly inbeveled basal portion; exterior border gently arched, very gradually converging toward the obtuse or sharply rounded anterior angle, the basal portion projecting more or less beyond, and well defined from the rounded coronal border; anterior and posterior margins making the same slight sigmoidal curvature, with a shallow concavity in front and a corresponding broad convexity behind from the inner angles, the basal portion all around more or less distinctly marked by vertical rugosities. The greater area of the coronal region is occupied by the broad low convexity of the inner prominence, which is rounded to the inner border, and on the other hand slopes into the narrow shallow depression bordered by the narrow fold along the outer border: in front, the coronal prominence presents a lunate, slightly depressed area, extending back from the anterior margin a greater or less distance, evidence of wear while in use. The surface presents, apparently, the same character of punctation observed in the above noticed form. Greatest transverse diameter across the posterior margin, 35 mm.; length along inner border, 26 mm.; breadth at the anterior margin, 28 mm.

The present species, represented by the two above mentioned forms, is known from half a dozen individuals in a more or less imperfect state of preservation. A nearly perfect mandibular tooth, save for the mutilation of the outer posterior angle, from the Lower Burlington limestone, may not be distinguishable from less perfect specimens from the main fish-bed of the Upper Burlington in which occur the maxillary teeth described. The almost quadrangular shape of the form and its proportionately narrower transverse diameter are the only apparent characters inconsistent with their association with the typical example of the supposed maxillary form above noticed. The same horizon in the Upper Burlington limestone at Quincy, however, has afforded Professor Worthen a unique specimen of a tooth referable to the same form, which is distinguished by its narrow lateral diameter and more quadrangular outline, which, together with the course of the anterior and posterior margins, strikingly resemble the opposed form mentioned above; its transversely depressed coronal surface, however, clearly discloses its homological identity with the supposed maxillary form. Greater or less variability in the proportions of these teeth may be readily anticipated, and the latter example may be merely an unusually elongate tooth of the same species as that regarded as the type of the species, first described above. However, should this supposition prove to be erroneous, the last mentioned tooth would then be a unique representative of a distinct species, while the narrow tooth would probably be identifiable with the species to which the maxillary teeth described above belong.

The forms described differ in so marked a manner from those of the previously described species, *Psammodus Springeri*, *P. tumidus*, *P. turgidus*, as not to require special review of these distinctive features. The maxillary form offers a typical example of the genus, and which strongly resemble individuals of *P. porosus*, Agass. The specific name is given in honor of Mr. James Love, of Burlington, to whom we are indebted for many favors.

Geological position and localities: Lower and Upper Burlington limestone; Burlington, Iowa, and Quincy, Illinois.

PSAMMODUS GLYPTUS, St. J. and W.

Pl. XIV. Fig. 5, 6.

There are two imperfect specimens of large-size teeth in the collections representing opposed forms of the upper and lower jaws, which are distinguished by the very slight longitudinal convexity and by the following characteristics respectively: The form probably referable to the lower jaw is apparently subquadrangular in outline, the coronal surface regularly transversely arched into the low prominence which occupies the greater part of its area, a shallow depression extending along the outer border; the coronal belt in the anterior margin and inner border extends one-fourth or one-third the depth, and is marked by delicate vertical rugosities, and distinctly defined from the basal portion,—the posterior and outer sides unknown. The surface of the crown presents an elaborate sculptured appearance from the delicate rugosities which are disposed in longitudinal lines, a narrow worn belt along the anterior edge exposing the minute punctate structure, the surface here also showing faint transverse undulations. The supposed maxillary form presents a broad shallow concavity in the transverse diameter, and very gently arched longitudinally, the enamel forming a well-defined belt, deeper along the inner articular border than at the anterior (?) margin, which is rather strongly inbeveled. The coronal surface presents an exceedingly intricate rugose ornamentation, the rugosities apparently not conforming to any definite direction. The examples attain a breadth of 30 to 50 millimetres, but they are too imperfect to show details other than those noticed.

The first noticed form bears marked resemblance to the corresponding form of *Psammodus Lorianus* in outline and contour, so far as these features are decipherable, and the peculiar rugose ornamentation of the coronal surface may be that of a tooth which has been less exposed to wear than the examples noticed under the latter specific designation. Still the present tooth differs from that form in having a more angular inner border, the crown in *P. Lorianus* being rounded to the enamel belt of the articular border. In relation to the companion tooth described above, its mutilated condition hardly affords the necessary data for the restoration of its outline and coronal contour, but the beautiful ornamentation of the surface is well displayed. In the latter character the tooth departs so widely from the specimen with which it is provisionally associated that we are inclined to regard their specific identity as improbable. In the peculiar sculpturing of the coronal surface it bears greater resemblance to the Keokuk species, *P. grandis*, though the disposition of the rugæ is much less regular than obtains in the latter species.

The same formation affords a fragment of a small tooth belonging to the form individuals of which we have elsewhere noticed under the specific designation *Psammodus crassidus*. The specimen preserves only a part of the outer border, which shows a somewhat oblique direction, making an obtuse angle with the anterior margin and which is strongly beveled from the acuminate culmination of the outer coronal ridge; the crown is rather deeply depressed transversely, and very moderately arched longitudinally, presenting a beautifully sculptured surface which bears a striking resemblance to the style of ornamentation observed in the typical specimen above described. The specific identity of the present example with that form, however, is merely conjectural. The specimen is of especial interest from the fact that it belongs to an opposite row,—all the individuals of *P. crassidus* at present known being from the same side.

Geological position and localities: Upper Burlington limestone, main fish-bed; Quincy and Cedar Creek, Henderson county, Ill.

PSAMMODUS GRANDIS, St. J. and W.

Pl. XV, Fig. 1-3.

Teeth attain large size. Maxillary form subrhomboidal in outline, moderately arched longitudinally, gently depressed transversely. Inner articular border nearly straight,—one specimen showing a slightly truncated posterior angle for the lesser articular facet, while a smaller individual shows a faint angulation a little in advance of the middle, but so disfigured by abrasion as not to clearly show its character. Coronal enamel forming a narrow fold more or less well defined from the deep basal portion; outer border not preserved; anterior margin very gently curved or nearly straight; posterior margin gently arched, more or less irregularly undulated, especially in mature teeth. Coronal surface in young examples smooth and regularly convex and concave in the two diameters, maturer individuals being traversed by more or less conspicuous transverse undulations, and which are even faintly discernible in the earlier-formed smaller teeth. The surface is elegantly sculptured, the rugose lines showing a decided transverse arrangement, though sometimes taking an oblique course over limited areas, and in the more exposed parts presenting a reticulate appearance like Arabesque designs, and in worn surfaces becoming obsolete where the ordinary minute punctæ appear. A small tooth presents the following relative proportions: Breadth across posterior margin, about 30 millimetres; breadth across anterior margin 24 mm; length along inner articular border about 20 mm.

Mandibular teeth subquadrangular in outline, rather strongly arched from within outward. Lateral borders unknown. The anterior and posterior margins marked by a narrow coronal fold well defined from the basal portion, which latter in front is slightly channeled with a corresponding convexity along the posterior margin. The coronal region, besides the rather strong longitudinal arching, presents a gentle transverse convexity, which probably occupies the greater extent of the coronal area. The anterior half or more of the surface is occupied by a transverse prominence, behind which the surface steeply slopes to a wide plane area bordering the posterior margin, presenting a contour somewhat corresponding to that of mature examples of the opposite jaw. The rugose ornamentation and punctation of the coronal surface presents a repetition of the characters noted in connection with the maxillary form. The imperfect sole representative of the form shows a longitudinal diameter of 90 millimetres, indicating the huge dimensions attained by the fishes represented by the present teeth, and which was, so far as we are aware, the largest of its kind.

The above species is known to us from a couple of imperfect teeth referable to the upper jaw, and a narrow section of a gigantic specimen belonging to the opposite jaw or mandible. The smaller of the maxillary teeth shows scarcely a vestige of the rugose coronal ornamentation, the surface on the contrary being densely occupied by the exposed orifices of the vertical tubes, which exhibit various stages of wear, from the simple punctæ of excessively abraded areas to the crater-like form surrounded by a rim of intensely hard substance, the punctæ simple or confluent, with discernible traces of the coarser prismatic structure. We are inclined to regard this tooth, at first sight so dissimilar in its superficial aspects, as specifically identical with its associates. It is an extremely rare species, and we regret the lack of materials necessary for a comparison with the forms of the typical European species with which it shares many points of resemblance.

Geological position and localities: Keokuk limestone, Keokuk and Bentonsport, Iowa.

Psammodus plenus, St. J. and W.

Pl. XVI, Fig. 1-4. Pl. XVII, Fig. 1-4.

Teeth attain large size. Form supposed to pertain to the upper jaw subrhomboidal, or of a laterally elongate-trapezoidal outline, gently arched antro-posteriorly. Margins nearly parallel, somewhat irregularly undulated, making a shallow concavity and then very slightly arched toward the antero-lateral angle, the reverse occurring in the posterior margin where the concavity is in the approach to the postero-lateral angle, both margins inbeveled or perpendicular to the crown surface, the anterior having greatest apparent obliquity, and defined above by the narrow coronal belt which constitutes less than one-fourth the depth of the face; the inner border is nearly straight, showing a faint angulation a little posterior of the middle, and a narrower truncated articular facet at the posterior angle, the coronal folds of the margins forming a continuous belt well defined from the moderately channeled basal portion, which terminates inferiorly in a narrow rim; the outer border is very gently arched, converging at an angle of about 15°, more or less, with the opposite border, and generally sharply rounded at the anterior angle, terminating in a more or less produced, acute angle posteriorly; in small or earlier-formed teeth the outer border is sharply inbeveled above and somewhat deeply channeled, limited by the narrow flange or basal rim below; but in larger individuals the basal portion increases in prominence, forming a massive border extending considerably beyond the coronal limits and terminating in a more or less produced spur at the posterior angle. Coronal surface smooth, gently arched longitudinally and between the lateral borders, making a broad, shallow concavity, forming an angle along the inner border and sharply rounded in the narrow coronal fold along the outer border, where it is well defined from the basal portion in small and large examples alike. The crown surface is uniformly minutely punctate, the pores being considerably spaced and confined within the easily discerned vertical prisms. However, the surface structure varies according to the state of preservation. In much worn examples the punctæ are coarse and crowded, while in others under an ordinary lens the radi of calcigerous tubes around the orifices of the pores and the minute prismatic structure of the inter-spaces are beautifully revealed. Again, the lines of growth generally describe a segment of a broad circle with the convexity toward the posterior margin, showing that the formative nucleus was situated nearly midway the anterior margin; in excessively worn individuals, whether from use or abrasion subsequent to dislodgement from the jaw, the posterior margin presents a broad convexity between the posterior lateral angles, markedly in contrast with the actual curvature in perfect teeth. A small tooth measures in greatest diameter across the posterior margin 29 millimetres, length along inner border about 16 mm. The perfect state of preservation of many of the specimens afford a fine exhibition of the character of the inferior surface, and which is applicable to all the species of the genus to greater or less degree. Conforming in a general way to the coronal contour, it is enveloped in a thin smooth layer of dense matter faintly striated longitudinally, forming a low ridge or angulation about one-third the distance from the inner border from which the surface regularly slopes to the lateral borders, the tooth showing its maximum depth at the posterior margin.

Teeth supposed to have been opposed to the preceding form, or pertaining to the mandible, are distinguished by their subquadrangular outline and relatively narrower transverse diameter compared to the length. The anterior margin is broadly arched forward with a slight concavity near the inner angle, which is slightly auriculate and sharply rounded at the outer angle; the posterior margin presents essentially the same outline, both margins faintly channeled, the posterior one most strongly inbeveled, the anterior nearly vertical. The inner border is nearly straight, making a faint angulation a little posterior of the middle in medium-size teeth, a slight articular facet occurring at the truncated posterior angle, the articular face faintly channeled and somewhat strongly inbeveled; outer border very gently arched and gradually converging anteriorly, basal portion in small and medium-size teeth rather deeply channeled, in larger specimens showing a thick rim extending considerably beyond the coronal limits and terminating in a produced spur posteriorly. The coronal surface is very gently arched longitudinally forward from the rather steep declivity bordering the posterior margin, and gently convex transversely, a narrow channel bordering the inner and posterior sides, which, together with the anterior margin, are defined by an abrupt angle, the coronal enamel forming a narrow fold encircling the tooth; along the exterior border the coronal surface is ordinarily abruptly rounded to the angular demarkation between crown and base, but in large teeth this angle is less prominent, though the coronal limits are still well defined; a slight longitudinal depression is discernible a little within and parallel with the outer border. The surface is smooth and full, the superficial structural details exactly agreeing with those observed in the preceding form. In the unworn rounded outer border of one or two specimens the coronal enamel presents faint rugosities apparently conforming to the lines of growth, and which must have produced an exceedingly delicate sculptured appearance in the surface. A small individual measures in transverse diameter across the posterior margin 13 millimetres; length along the inner border 14 mm. A medium-size specimen is 35 mm., and 26 mm. in the same dimensions; and the largest individual as yet observed shows a lateral breadth of 53 mm.

The above described forms undoubtedly pertained to one and the same species. They occur in the collections in about equal numbers, and present precisely the same superficial features in all respects save outline and contour. The supposed maxillary teeth apparently vary but little in proportions. The larger teeth differing from the small ones chiefly in the greater basal development in the region of the outer border. A fragment of a very large tooth obtained by Mr. Alexander Butters, representing an individual which was probably not less than 90 millimeters in lateral diameter, presents the same coronal contour in every particular, save the rounded posterior angle of the inner border and the irregular, deeply scolloped posterior margin, which may be likened to a line of overhanging cliffs. The latter specimen is also of interest on account of showing the permanence of depth maintained by the enamel belt, which is disproportionately shallow as compared with the relative dimensions of the tooth, while the basal portion is excessively developed.

In regard to the supposed mandibular teeth, there is observable a much greater latitude in variability, especially in the proportions, with age. The earlier formed teeth are relatively longer, while the larger individuals show a greater transverse breadth, with which latter character is also associated that noted in large examples of the opposed form, in which the basal portion is developed into a prominent flange along the exterior border. The collections contain two large teeth, which differ so greatly from the normal condition of medium and small-sized examples, that they might be mistaken for representatives of a distinct species. The latter teeth are very broad compared to the length, and to further obscure their probable actual specific identity, the posterior margin is in both cases broken away, its outline conforming to the backward-arched lines of growth, instead of presenting the forward curvature or moderate concavity characteristic of perfect teeth. The anterior margin, also, shows an accurate outline, with auriculations at either angle, which may be attributable in part to wear from the severe usage to which the teeth were subjected during the life of their possessor. The backward curvature of the lines of growth, which appear to be indicated by alternating belts slightly varying in density and hardness, are the same as above remarked in the maxillary form.

It is a singular, not to say extraordinary, circumstance that none but left-side individuals of the supposed maxillary form and right-side teeth of the mandible exist in the collections, which contain a score and a half of specimens in all conditions of preservation. Supposing the teeth to have been ranged in double rows upon the jaws, the impingement of individuals of opposite rows at their oblique articular inner borders gives to the transverse section a marked concavity, while the inbeveled apparent obliquity of the anterior and posterior margins indicate a considerable fore and aft arching in the coronal contour of the series of maxillary teeth. The individuals of the opposed mandibular form, viewed in the same relative position, present contour diametrically opposite to those noted in relation to the maxillary series, the transverse section of the double row showing a convexity conforming to the concavity of the opposed series, though the longitudinal arching of the series of the latter form was perceptibly less than that of the mandibular series. The latter observations apply to the small and medium size teeth, but in the large mature teeth the longitudinal convexity of the crown seems to be more pronounced, which would give to the series of teeth upon the jaw a greater relative convexity from behind forwards. However, it will have become apparent, that there is intimate correspondence in the coronal contour and co-adaptation of triturating surface in the two forms here associated under the same specific designation. And, however large the materials in our possession, it is hardly more than suggestive of the complete history of the species they represent.

An imperfect tooth from the same formation at Grand Rapids, Michigan, kindly submitted to us for examination by Prof. E. A. Strong, appears to be intimately allied to the present species. The specimen is also a left-side tooth of the mandibular form, from which the enamel layer has been exfoliated, revealing a beautiful punctate surface quite in contrast to that usually prevalent in the teeth derived from Missouri and Illinois localities. The medullary tubes are raised into crater-like prominences encircled by delicate radi, giving to the surface a beautiful stellate ornamentation very like that so commonly met with in the teeth of Cochliodonts. The general outline agrees with that of typical examples, the posterior margin in the worn condition conforming to the bands of growth; but the coronal contour shows a greater fullness in the inner half, in which particular it bears greater resemblance to the Chester species *Psammodus angularis*, N. and W. However, similarly preserved examples from Alton show a less regular concavity in the transverse profile and corresponding fullness in the inner half, approximating the conditions observable in the Michigan example. It is much to be desired that larger materials from the latter quarter be obtained, in order to trace more definitely the characteristics of its piscine fauna and its relations to that of the southern and southwestern areas of the same deposits.

The maxillary tooth bears somewhat marked resemblance to the same form of teeth occurring in the Upper Burlington limestone, *Psammodus Lovianus*, but the associate mandibular teeth are quite different from those identified with the latter species, as will be manifest on comparison of the illustrations given of the two species. We regret the lack of material permitting detail comparison with the European species *P. porosus*, Agass., although little doubt is entertained respecting the specific distinctness of the above described forms.

Geological position and localities: Not uncommon in the St. Louis limestone; St. Louis, Mo., Alton, and Monroe Co., Ill., Grand Rapids, Michigan.

PSAMMODUS CÆLATUS, St. J. and W.

Pl. XVIII. Fig. 1.

A fragment of a small tooth from the St. Louis formation at Pella, offers so well-marked peculiarities that we have decided to notice it under the above designation. It is homologous with the form elsewhere referred to the upper jaw, and is distinguished from *Psammodus plenus*, of the same formation, by the concavity in the curvature of the outer border, the strongly produced postero-outer angle, more strongly inbeveled anterior basal wall, and the rugation of the coronal surface, which presents a very moderate longitudinal convexity and transversely depressed contour. The length of the tooth along the outer border between the acute posterior and the sharply rounded anterior angle is about 11.5 mm., the basal rim somewhat expanded laterally and produced posteriorly, increasing the length of the border to about 13 mm. The transverse diameter across the posterior margin exceeded 13 millimetres; in consequence of the mutilation of the inner articular border the entire breadth of the tooth is not shown. The posterior margin is somewhat deeply concave in outline, the anterior extremity was apparently gently arched or nearly straight, but it bears evidences of wear by which its outline is made to appear slightly concave, the coronal margins well defined from the base, making a slight angulation in front and behind sharply defining the inbeveled inferior basal face.

The above described tooth is peculiar in outline, but the coronal sculpturing resembles that of *Psammodus glyptus*, also *P. reticulatus*, N. and W., of the Chester limestone, although it cannot be confounded with either of those species. The rugæ show irregular disposition, in which particular the tooth contrasts with the superficial ornamentation observed in individuals of the form referred to *P. crassidens*, while it represents a different form from that upon which the latter species was based.

Geological position and locality: St. Louis formation, Pella, Iowa.

PSAMMODUS CRASSIDENS, St. J. and W.

Pl. XVIII. Fig. 2-6.

Psammodus rugosus, NEWBERRY and WORTHEN, 1866, Illinois Geol. Surv., II, p. 108, Pl. XI, f. 3, 3 a. Not *P. rugosus*, Agassiz.

Teeth attain large size, subrhomboidal in outline. Coronal surface moderately arched from behind forwards, somewhat steeply sloped in the region of the anterior margin, with a distinct longitudinal median depression, bordered on either side by a moderately prominent fold rounded to the lateral borders, where the coronal enamel is more or less distinctly defined from the basal portion of the tooth. The outer border is gently arched, rather sharply rounded into the anterior margin, terminating posteriorly in an acute angle; anterior margin also broadly arched from the rounded outer angle to the subacute inner angle, presenting in unworn individuals a sharp edge inferiorly inbeveled with the basal portion; posterior margin closely repeats the curvature of the opposite extremity, sometimes interrupted by undulations, and terminating in sharp angles; the inner border conforms in a general way to the curvature of the opposite side, but toward the anterior extremity the tooth is laterally expanded, dividing the articular border by a more or less conspicuous angulation into two distinct areas somewhat variable in extent. The basal portion of the tooth is very deep, the outer border considerably expanded beyond the coronal fold, more or less produced at the posterior angle, and inbeveled below to the relatively reduced inferior surface; inner face broadly channeled and interrupted by the before-mentioned angulation; anterior face also excavated vertically and somewhat inbeveled from the plane of the coronal surface; posterior margin presenting a shallow vertical concavity,—the edges all round making an angle, except along the outer side, with the inferior surface, which latter shows a faint median ridge. The coronal surface presents a minute punctate structure, the pores somewhat widely spaced, sometimes confluent, and enclosed in the usual vertical prisms. Toward the posterior margin there appear indications of transverse rugæ. The basal walls are vertically and irregularly plicated, and perforated by the irregular pores and occasional alviolar cavities; the abraded inferior surface shows delicate vermiculose markings, but in the perfect state it presents the usual dense, smooth layer, which also envelopes the walls of the base. A large-size perfect tooth measures across the posterior margin 32 mm., and about 25 mm. across the anterior extremity; length along inner border 45 mm.; depth of tooth at the posterior margin 21 mm., and 20 mm. at the opposite extremity.

The collections afford four or five examples of a form of teeth, which, in their coronal contour and general conformation, also in the details of their superficial structure, show unmistakable relationship with *Psammodus*, although they present a type differing in certain well-defined characteristics from the previously herein described species of the genus. The first authentic example of the form here alluded to is that described by Professor McCoy[1] under the name *P. canaliculatus*, from the mountain limestone of Ireland. The examples before us all belong to the same side, while that figured by Professor McCoy represents a tooth from the opposite side. As in the previously described forms, the character of the articular walls clearly indicate the paired arrangement of the teeth,—indeed in the instance of the Upper Burlington species, *P. Springeri*, the examples from opposite rows are about equally represented in the collections, and the same may be said of the European species, *P. porosus* and *P. rugosus* (sp. ?) of Agassiz. While this statement is true so far as it goes, and the form in question doubtless occupied a lateral position upon the jaws, we have yet to ascertain the relative disposition of the individual teeth thereupon. The peculiar character of the inner articular border permits of coadaptation neither with opposites of the same form, nor with the other forms with the remains of which the present one is associated, and we are left in doubt even as to the generic identity of the latter. The crescent-shaped outline of the inner articular faces indicate a corresponding convexity for the outer border of the teeth of the contiguous row articulating with this form. The space intervening between opposite individuals of the form is lingulate in shape, but whether it was occupied by a single row of lingulate teeth, or that these were further subdivided can only be conjectured. On the other hand, if the dental formula ascribed to the Upper Burlington species, *P. Springeri*, which seems to be well founded, attributing to it a simple biserial arrangement, be regarded as typical of the genus, then we should have in the present form a new element further complicating the dental formula to an extent which, if met with in existing Myliodonts, might constitute a distinctive feature of generic significance. We are, however, fully cognizant of the meagerness of the data at this time possessed, and would clearly discriminate between the facts themselves and that which they suggest with greater or less degree of plausibility.

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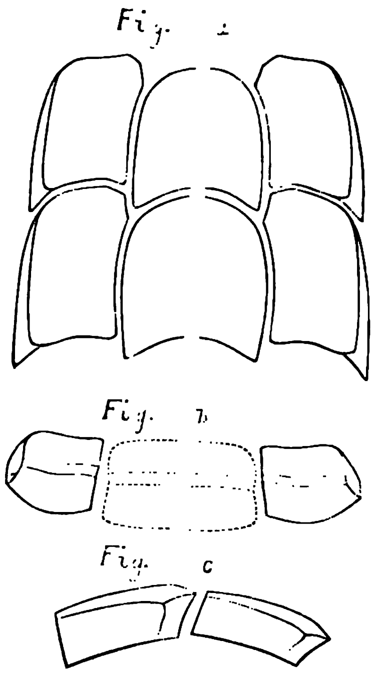
[1] British Palæozoic Fossils, 1855, p. 643, Pl. 3 G, f. 12.



Psammodus crassidens.

The accompanying diagram represents the simplest dental combination of the form here particularly alluded to. The lingulate teeth of the median row certainly offer strong resemblance to some of the generic forms with which *Copodus cornutus*, Agass., is associated; but none such have been recognized in the present case. True, we have a form occurring in the same horizon with the present species which is referable to the latter group; but it clearly has no intimate relationship with the form in question.

The few individuals mentioned above as comprising the sole representatives of the present form occurring in the St. Louis limestone, vary considerably one from the other. The large, normally entire tooth in the collection of Mr. Van Horne is supplemented from the same locality by a proportionately shorter tooth, which has the angulation of the inner articular border situated nearer the middle of the tooth instead of one-fourth the distance from the anterior extremity as in the specimen just mentioned, with which it exactly agrees in other particulars. A third example from the same locality, at Alton, offers still other differences, as in the obliquity of the anterior margin, the angulation of the inner border being crowded forward and merged with the inner lateral angle, the stronger developement of the outer basal rim, and the prominent transverse rugæ that envelope the posterior two-thirds of the coronal surface, the anterior slope and the ridge parallel with the inner border being worn smooth, revealing the ordinary punctate structure noted in the above mentioned specimens. A smaller tooth derived from the same formation, at Pella, differs from the above in the very slight developement of the angulation in the articular border, which is situated about one-third the distance from the anterior angle; the coronal fold also shows a sharp angulation along the vertical inner border, but the opposite border is worn away, destroying every vestige of the prominent basal rim usually occurring along that side of the tooth, though the basal region is otherwise very like that described from normally preserved specimens. The coronal surface, however, is worn quite smooth, showing the ordinary punctæ. We are inclined to regard all of the above mentioned specimens as probably pertaining to one and the same species, the variable condition of the coronal surface being due to the effects of trituration, and the other peculiarities, as the position of the angulation in the inner border, such as may be attributed to individual variation. This inference, however, may appear inconsistent at first sight, but we have already observed marked variations in the same parts, as noted in individuals described under *Psammodus plenus*, of whose specific identity scarcely a doubt can arise.

The specimen figured in Pl. XI, f. 3, 3a, of Vol. II., Ill. Geol. Survey, where the form is referred by Messrs. Newberry and Worthen to *Psammodus rugosus*, Agass., also represents a short tooth, in an almost perfect state of preservation, save the wearing away of a patch of the crown at the outer anterior angle. It presents a rhomboidal outline, the anterior margin gently curved forward, the deep basal portion inbeveled, the posterior margin correspondingly curved: the outer border broadly arched, the basal portion projecting in a prominent, thick rim beyond the coronal limits, slightly produced posteriorly, and inbeveled to the inferior surface; the inner border presents precisely the conformation observed in typical examples, except that the angulation is placed forwards a little less than one-fifth the distance from the anterior angle, distinctly defining the anterior articular facet from the long posterior articular surface. The coronal surface is longitudinally moderately arched, and transversely depressed, limits of the crown well defined at the sides, the inner ridge presenting the abrupt face noticed in the above mentioned example from Pella; the outer ridge also rises into a low acumination nearest the anterior angle. The worn surface exposes the usual minute punctate structure, but in the more depressed portions which have escaped abrasion, the transverse rugæ are discernible, the same as noted in one of the Alton specimens of a very elongate tooth.

The present species differs equally from that noticed from the Upper Burlington limestone, and *Psammodus canaliculatus*, McCoy, of the Irish Mountain limestone: Relatively shorter than the latter, from the former it may be distinguished by the less prominent and more rounded contour of the coronal ridge along the outer border.

Geological position and localities: St. Louis formation; Alton, Ill.; Pella, Iowa.

Psammodus angularis, N. and W.

Pl. XIX, Fig. 1, 2.

Psammodus angularis, Newberry and Worthen, 1866, Ill. Geol. Surv. II, p. 107, Pl. XI, f. 1, 2, 2a, 2b.

Psammodus porosus? Agass., ib., p. 107, Pl. XI, f. 1, 1a, 1b.

The above designated species was described from a nearly perfect example belonging to the form provisionally referred to the mandible. In order to facilitate comparison with the forms described in preceding pages, we venture to supplement the brief description above cited by a somewhat detailed notice of the species, based upon the original example and the few additional specimens subsequently discovered in the same horizon whence the type was derived.

The supposed mandibular teeth attain medium size, showing a trapezoidal outline. The coronal region is moderately and regularly arched from behind forwards, gently depressed transversely, with, however, a fullness in the inner half or more of the area, which amounts to a slight convexity in the long diameter of the tooth, the outer border being well defined by a narrow ridge, separated from the convex inner area by a shallow, longitudinal depression. The anterior margin is gently arched, with a slight concavity near the inner angle and rounded into the outer border at the opposite angle, the inbeveled basal portion meeting in a sharp angle with the coronal surface; posterior margin describing approximately the same curvature, the crown defined by a sharp angle, the slightly-inbeveled basal portion channeled, the upper portion enveloped in a glassy, enamel layer; outer border gently arched, terminating posteriorly in a more or less produced spur, the narrow coronal ridge rounded to and well defined from the basal rim, which latter is not sufficiently well-preserved to show its actual outline and magnitude. The inner border is nearly straight, with a slightly-oblique course forward and outward, and faint angulation near the anterior angle, the crown making a sharp angle with the channeled basal wall, and margined by a slight-impressed line, forming a narrow border encircling the contiguous sides of the crown. The inferior surface, in the perfect state, shows irregular striato-punctation in the slightly-concave, longitudinal direction, with a slight elevation about one-third the distance from the inner border, where the tooth attains its maximum depth. The coronal surface is uniformly minutely punctate, plainly exhibiting the superficial structural features common to the congeneric forms. Transverse diameter across the posterior margin, 29 mm.; length along inner articular border, 17 mm.; greatest depth of tooth, 6.5 mm.

Worn examples of the above described form show a greater transverse convexity of the coronal surface, while the edges are rounded, obliterating the narrow, impressed border mentioned above; it is not improbable also the outer ridge may become nearly obsolete in similarly preserved specimens. The homologous form of the St. Louis species *Psammodus plenus* presents a striking contrast to the present teeth, being proportionately longer, with less inbeveled posterior and anterior walls, and greater lateral convexity of the coronal surface. Indeed, the nearest allied species at present known is that from the Upper Burlington, *P. Springeri*, the corresponding form of which differs in the directly opposite direction of the obliquity of the inner articular border, greater length, and more produced posterior angle of the outer border.

In accordance with the presumed homological relations of the various forms of teeth ascribed to the genus, the form pertaining to the upper jaw of the above species is recognized in the teeth which Messrs. Newberry and Worthen identified with *Psammodus porosus* of Agassiz. These teeth are evidently most intimately related, so far as may be judged from the similarity in the details of their superficial coronal structure, which is, indeed, identical in both of the forms. We are, therefore, convinced that they represent forms of one and the same species, presenting the same combination of dental apparatus observed in the several species described in the foregoing pages.

The latter form is distinguished by its transversely elongate trapezoidal outline, the course of the lateral borders, and general contour of the coronal region intimately repeating those parts as observed in *Psammodus plenus*, of the St. Louis formation. The inner border, which is similarly marked by a slight angulation a little in advance of the middle, shows a distinct truncation of the posterior angle with a narrow articular facet. In the character of the anterior and posterior margins, also, intimate resemblances are noticeable with the above species. But the examples of the present form are appreciably of greater depth and more solid or massive proportions, and the punctæ of the coronal surface are also perceptibly firmer and more numerous even than remarked in the corresponding teeth of *P. plenus*. A mature tooth measures in greatest transverse diameter across the inner margin 39 mm.; length along inner border 23 mm.; greatest depth of tooth 10 mm.

Together with the associate form, both forms occurring in the same horizon, the species is readily distinguished from that with which it has already been compared, and of which it is an interesting example of a representative species. As regards their relations with the European teeth originally described by Professor Agassiz under the name of *Psammodus porosus*, we deem it hardly probable that that species is so variable as to include the present forms.

Geological position and locality: Chester limestone; Chester, Illinois.

PSAMMODUS RETICULATUS, N. and W.

Pl. XIX. Fig. 3, 5.

Psammodus reticulatus, NEWBERRY and WORTHEN, 1866, Ill. Geo. Sur., II, p. 109, Pl. XI, f. 5, 5a.

Besides the type specimen, the collections from the same horizon whence that was derived contain other imperfect examples, apparently representing the two forms ascribed to the upper and the lower jaws, which are believed to be specifically identical with the tooth originally noticed by Messrs. Newberry and Worthen. The original specimen is probably that of an immature tooth which had not been brought into use prior to the destruction of its possessor, and it is owing to this fact that it presents merely the coronal crest or shell entirely detached from the base, which was of a coarse porous structure and less solidified than the layer more strictly pertaining to the coronal region; also to the same state of things is doubtless attributable the very perfect state of preservation of the rugose ornamentation, which in this instance occupies the entire coronal surface. Fragments of teeth identical in contour and ornamentation are readily identified with the above specimen; but others bearing unmistakable evidence of excessive abrasion while in use, present a nearly plane coronal surface with only traces of the rugæ remaining in the more depressed portions of the surface. The latter, from the general outline, apparent original contour, and the posteriorly gently convex course of the transverse depressions which also correspond with the lines of growth, strongly indicate their identity with the original specimen, and it is with the aid of these maturer examples that the outline of the form may be more definitely sketched, the type specimen being imperfect at either lateral border.

The type example is probably a representative of the form provisionally identified with the upper jaw. The teeth attain medium size, quadrilateral in outline. In more or less worn specimens, the usual condition of the examples that have been found, the coronal region presents a moderate longitudinal convexity, and a slight transverse concavity, in which direction the surface shows a more or less distinct undulation, the plane posterior slope preserving traces of the original rugose ornamentation. The coronal surface of unworn teeth, like the type specimen of the form, shows a rather strongly arched contour from behind forward, produced by a conspicuous transverse ridge, from which the surface gently slopes with slight concavity to the anterior margin, more steeply sloped behind to a slight impressed angle, whence the surface presents a nearly plane area of variable width, terminating in the posterior margin, and irregularly undulated longitudinally; the crest of the transverse ridge is gently sagged throughout the greater part of its extent, and on nearing the outer (?) border it is somewhat steeply sloped into what appears to have formed a shallow, narrow depression just within the outer coronal fold; even in worn examples the latter conformation of the coronal surface is more or less discernible, but the inner border is angularly rounded to the nearly vertical articular wall, which latter shows a slight concavity between the angles, the anterior angle distinctly truncated for the narrow oblique articular facet. Anterior and posterior margins parallel, nearly straight, or gently arched forward with a slight concavity toward the inner angle in front, and a corresponding convexity in the posterior margin, inbeveled to the basal portion, which was of proportionate vertical depth. The basal support of the borders is not preserved. The surface of unworn teeth exhibits an exceedingly intricate reticulated ornamentation, produced by the rugæ occupying the interspaces between the punctæ, the prevalent continuity having a transverse direction; on the other hand, worn surfaces show rather coarse, crowded punctæ, confluent in the depressed transverse belts. Lateral diameter of a medium-size smooth tooth across the posterior margin, 37 mm.; length along inner border, 22 mm.; depth of tooth, at least 8 mm.

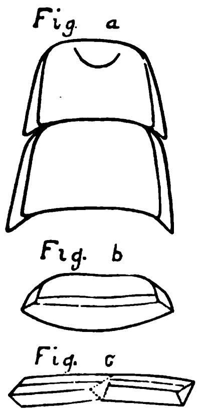
Professor Worthen has obtained from the same deposits, and associated with the foregoing teeth, a single imperfect example of a tooth which may prove to be identical with the opposed mandibular form of the present species. It shows a medium size tooth, quadrilateral in outline, the worn anterior margin slightly arcuate, though originally probably gently arched, corresponding approximately with the moderate concavity of the posterior margin, inner border making nearly a right-angle with the margins, posterior angle truncated, with a rather prominent angulation about one-third the distance forward; outer border unknown. The crown is well defined all round from the deep, slightly excavated basal walls, which are inbeveled—strongly so along the anterior margin. The latter feature accords with the rather marked convexity of the coronal region from behind forward, giving to the series of teeth a strongly rolled longitudinal section, the surface showing a faint transverse furrow in the anterior half, where, as also in the slope bordering the posterior margin, the surface presents the same rugose ornamentation described in connection with the previously mentioned form, the more exposed parts showing a smooth, densely punctate surface. The coronal area is nearly plane, or faintly depressed transversely, with a slight depression parallel with the outer border, and showing a fullness somewhat contrasting with the opposed maxillary form. Transverse diameter at the posterior margin, at least 40 mm.; length of inner border, 22 mm.; vertical depth of tooth, at least 10 mm.

While the previously noticed maxillary form hardly requires detail comparison with the homologous form of *Psammodus angularis* occurring in the same deposits, it possesses characters of a much more intimate nature in common with the same form of *P. grandis* of the Keokuk limestone. But besides its much smaller size, the mandibular form departs widely from that of the Keokuk species, as will be apparent on comparing the coronal contour of the two species, as shown in the illustrations. The mandibular tooth bears some resemblance to the maxillary form of *P. angularis*, but besides its rugose ornamentation, the punctæ exposed in the worn surfaces are perceptibly coarser and more crowded than observed in that species, which shows a uniformly minutely punctate surface, the punctæ being rather widely spaced.

Geological position and locality: Chester limestone, Chester, Illinois.

GENUS COPODUS, Agassiz.

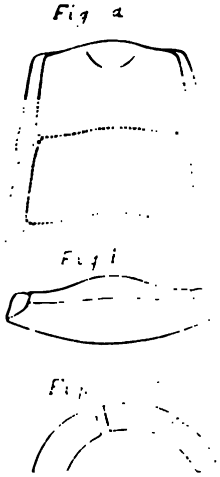
Copodus, AGASSIZ, MSS., 1859. (*Psammodus cornutus*, Agass., 1838, Poissons Fossiles, tome III, p. 174; Catalogue of Type Specimens of Fossil Fishes in the Museum of the Earl of Enniskillen at Florence Court, Ireland, Geol. Mag. VI, 1869; Dr. John J. Bigsby, 1878; Thesaurus Devonico—Carboniferus; etc.



GENUS COPODUS.
Maxillary form.
Fig. *a*. Triturating surface.
Fig. *b*. Transverse profile from inner margin.
Fig. *c*. Longitudinal profile.

Teeth bilaterally symmetrical, spanning the jaw without mesial suture, arranged in a single longitudinal series from behind forwards. Lateral borders gradually converging anteriorly, where they make an obtuse angle with the convex anterior margin, posteriorly produced into an acute angle meeting the lateral extremities of the concave posterior margin. Coronal region slightly arched longitudinally and laterally, distinctly defined from the base. The lateral borders of the base form a more or less prominent rim projecting beyond the coronal limits, beveled or rounded inferiorly and more or less produced at the postero-lateral angles. The anterior and posterior walls vertical to the plane of the crown surface and channeled. Inferior surface regularly arched transversely, and gently concave longitudinally in conformity with the arched coronal contour, the tooth attaining maximum depth along the mesial line at the posterior margin. The crown may present a lunate depression extending a greater or less distance backward from the anterior margin and of variable depth, which is due to abrasion while in use. The coronal surface is enveloped in a thin layer of enamel, beneath which as also in the worn areas the punctate structure is clearly discernible, the puncta inclosed in vertical prisms, as also observed in relation to the superficial structural features of ***Psammodus***.

The foregoing diagnosis applies to a form which, from the moderate antero-posterior convexity of the crown, and which was communicated to the series of teeth, evidently pertains to the maxillary. Associated with the above form, Mr. VanHorne has discovered a fragment of a tooth, exhibiting precisely the same structural features above noticed, which we are led to regard as the representative of the opposed form belonging to the lower jaw.



COPODUS.
Mandibular form.
Fig. *a*. Triturating surface.
Fig. *b*. Transverse profile from inner margin.
Fig. *c*. Longitudinal profile.

The latter or mandibular form, in a general way agreeing in outline with the maxillary teeth, is distinguished by its relatively greater transverse diameter as compared to the length, strongly arched longitudinally, with a narrow depressed belt parallel with the lateral borders of the crown which form a slightly upraised fold, beyond which the basal border extends in a prominent rim. The anterior and posterior walls of the base, as also the inferior surface enveloped in the dense layer protecting the coarser cellular structure composing the greater portion of its thickness, are precisely as observed in the above described form of the upper jaw.

The last noticed form is comparable to the teeth to which Professor Agassiz gave the name *Labodus*, of which two species are indicated, viz., *L. prototypus*, Agass., and *L. planus*, Agass., from the mountain limestone of Ireland. But in the present instance all the facts seem to point to generic identity with the first described form, which is unmistakably congeneric with the teeth designated by Professor Agassiz under the above generic appellation. As to the homological relations of the two forms alluded to above, to briefly recapitulate:—The slight longitudinal convexity of the first described form, indicating for the series of teeth associated in the same row a very moderately arched longitudinal contour; and in the case of the latter form the strong convexity of the crown from behind forwards, indicating a corresponding strongly rolled outline for the series of two or more individuals, in both instances constitute characters consonant with what actually obtains in forms of teeth of opposite jaws of Tertiary and existing Myliodonts.

The affinities of the Copodi are certainly with the Myliodonts, the single row of teeth, spanning the jaws like paving flags, finding a somewhat intimate repetition in the still existing genus *Aetobatis*. There are, however, other characters that offer marked contrasts in contradistinction of the ancient and the latter modern representative, and which probably should be interpreted as possessing an importance even of greater consequence than generic. The characteristics possessed in common with the genus *Psammodus*, Agass., show unmistakable family relationship with the latter, while structurally and in the character of the basal portion of the teeth there is even striking contrast to the features noted in typical Myliodonts. We are, therefore, of the opinion that the family distinctions of the Palæozoic teeth here alluded to are paramount and should be so recognized; hence the family designation *Psammodontidæ*, which was bestowed by Dr. de Koninck on this group of ancient selachian remains, is here adopted.

The genus appears to be restricted to the earlier groups of Carboniferous formations both in Europe and America.

COPODUS VAN HORNII, St. J. and W.

Pl. XX, Fig. 2, 3.

Teeth representing the forms pertaining respectively to the upper and the lower jaws, and which attain medium size.

Maxillary teeth lingulate in outline, very gently arched from within outward. Lateral borders nearly straight, gradually converging and angularly rounded into the anterior margin, posteriorly terminating in a produced spur, the basal portion projecting in a widish rim beyond the coronal limits, inferiorly inbeveled and rounded to the inferior surface; anterior margin regularly and moderately arched, the coronal band forming a coping constituting one-fourth or one-third of the depth, and well defined from the excavated basal portion; the posterior margin approximately conforms to the curvature of the opposite margin, and is similarly marked, the channeled basal portion in both instances irregularly vertically pitted. The coronal region is moderately arched transversely, flattened along the median line, with a lunate depressed triturating area reaching back from the anterior margin a greater or less dis-

[illegible] surrounded and defined from [illegible] the enamel terminating [illegible] The surface is [illegible] punctæ, the lateral [illegible] areas, enveloped [illegible] exceedingly delicate [illegible] posterior sides. Inferior [illegible] to the convexity of [illegible] slight median angula-[illegible] finely fluted longitudin-[illegible] diameter between [illegible] enamelled coronal area [illegible] along the median [illegible]

[illegible] same species that bore the [illegible] and coronal aspect. [illegible] greater breadth com-[illegible] contour of the [illegible] margin is somewhat [illegible] antero-lateral [illegible] at the median line, the in-[illegible] narrow belt, beneath [illegible] slightly channeled basal por-[illegible] unmistakable identity with [illegible] gradually converge, making [illegible] produced, the basal rim form-[illegible] slightly upraised along the outer side, [illegible] inferior surface; posterior mar-[illegible] approximating the curvature of the opposite [illegible]. Coronal surface strongly arched longitudinally, the transverse convexity moderate and regular, with a shallow, narrow depression parallel with the lateral borders, along which an exceedingly delicate fold defines the crown from the basal rim; in front the surface is worn into a lunate depression of greater or less extent and depth, the punctæ and the delicate rugose ornamentation of the enamel layer agreeing with the surface appearances noted in the opposed form; towards the posterior margin the surface shows distinct lines of growth, making a broad arch backward, and deflected on nearing the lateral borders, but which does not necessarily indicate the outline of the posterior margin, which doubtless in the perfect state presents a concavity corresponding to the convex outline of the anterior margin. Inferior surface moderately concave longitudinally, and quite strongly arched transversely, meeting at the median line in an obtuse angle, the dense surface layer longitudinally striated. Transverse diameter across posterior margin at least 22 mm.; length along the median line probably 12 mm.; greatest depth of tooth 6 mm.

The form first mentioned above, and which is regarded as having belonged to the upper jaw, presents as typical an example of the genus, as does *Copodus cornutus* of Agassiz. It is distinguished from that form by the more regularly arched outline of the anterior margin and the transverse convexity of the crown-surface, in the latter respect bearing greater resemblance to *C. spatulatus*, Agass., from which, however, it is distinguishable by the more constant posterior expansion of the borders of the crown proper.

The form pertaining to the mandible bears a striking resemblance to the teeth designated under the generic term *Labodus*, Agass., and which may well be supposed to be homologous with the present form. It differs markedly from the typical species indicated by Professor Agassiz, *L. prototypus*, from the Irish Mountain limestone, in the relatively great transverse convexity of the coronal surface.

The discovery of the above species adds another name to the long list of genera common to the Lower Carboniferous formations of the Old and New Worlds. The specific designation is given in honor of W. C. Van Horne, Esq.

Geological position and localities: St. Louis limestone; St. Louis, Mo., and Alton, Ill.

COPODUS PUSILLUS, St. J. and W.

Pl. XX. Fig. 1.

Teeth very small. Form pertaining to the upper jaw subrhomboidal in outline, lateral borders very gradually converging and somewhat sharply rounded into the slightly arched anterior margin, the worn tooth showing the posterior margin also broadly arched backward. The coronal region is gently and about equally arched in both directions, with a faint narrow depression near the lateral borders, which latter are bordered by a narrow fold beveled to and distinctly defined from the basal rim; in front the coronal belt forms a narrow lenticular strip inbeveled to the channeled basal wall, and above the usual lunate triturating area. The coronal surface was enveloped in a dense enamel layer marked by faint longitudinal rugæ, and showing beneath the vertical prismatic structure and punctæ, the latter minutely and closely pitting the worn areas in front; the crown also shows the broadly arched lines of growth to which the posterior margin in worn individuals more or less conforms. The basal portion of the tooth is not known. Transverse diameter of tooth across the posterior margin at least 9 mm; length along median line 7.5 mm.

The above described species is represented by a unique example discovered by Dr. George Hambach, showing nearly the entire coronal area, but the basal portion is destroyed, and the posterior margin worn even with the broadly arched curvature of the lines of growth. The postero-lateral cornua are also absent from the same cause; otherwise the specimen clearly displays its distinctive peculiarities. Compared with the preceding species from the St. Louis limestone, *Copodus Van Hornii,* the present form is distinguished by its more angular outline, the lateral borders much less rapidly converging anteriorly, and perhaps the more uniform convexity of the coronal surface. The specimen somewhat resembles certain forms from the Irish Lower Carboniferous deposits referred by Professor Agassiz to the intimately allied genus *Pinnacodus:* but if we correctly interpret the distinctive peculiarities of the latter genus, the present tooth differs in not possessing the emarginated anterior margin which characterizes that genus, as represented by the typical form *P. gonoplax,* Agass.

Geological position and locality: Chester limestone; Chester, Ill.

ICHTHYODORULITES.

GENUS CTENACANTHUS, Agassiz.

CTENACANTHUS COXIANUS, St. J. and W.

Pl. XXI, Fig. 1.

Dorsal spines attain large size, somewhat rapidly tapering, laterally compressed, presenting a wedge-shaped transverse section, moderately arched, and apparently but moderately inclined backward judging from the slight obliquity of the line of insertion as shown in the example before us. Anterior edge sharply rounded and occupied by a single carina interrupted by strong transverse ridges; lateral surfaces slightly convex, occupied by prominent costæ, flattened along their crests, and separated by deep, narrow sulci, increasing by occasional bifurcation, and ornamented by irregular transverse ridges, which present an abrupt declivity above and a more gentle convexity below, apparently smooth. Posterior face unknown. Pulp cavity apparently occupying less than half the antero-posterior diameter, and situated entirely within the posterior half of the spine. The specimen described attained a length of at least 150 millimetres; antero-posterior diameter at line of insertion probably 45 mm.; lateral diameter at same point 14 mm.

The above described species is recognized from a fragment of a large spine, which shows a length of 90 millimetres, including part of the base showing the line of insertion from which the comparatively erect position in the fish's back is inferred. Its relations are most intimate with *Ctenacanthus Mayi*, N. and W., of the Upper Burlington limestone, and the fish to which it belonged was a representative species of that to which *C. Mayi* pertained. These two spines are almost exactly of the same proportions and form. The Keokuk specimen is, however, somewhat more robust, and is further distinguishable by the greater width and depth of the intercostal sulci and relatively narrower costæ; the transverse carinæ or nodes along the anterior ridge are also narrower and less tumid, the costæ more frequently bifurcate, presenting less broad, flat surfaces toward the base, and the pulp cavity apparently has greater extent toward the extremity than is the case in *C. Mayi*. The posterior wall of the spine is destroyed, revealing the deep furrow of the pulp cavity the entire length of the fragment and which was probably closed to the line of insertion. In *C. Mayi* the posterior face was simply channeled and bordered by the lateral flanges, which show traces of the posterior denticles, also that the lateral surfaces bore longitudinal costæ quite to the posterior edges.

The unique example described was discovered by Mr. L. A. Cox, of Keokuk, in whose honor the species is dedicated.

Geological position and locality: Keokuk limestone; excavations for the Government canal round the Keokuk rapids, near Montrose, Iowa.

CTENACANTHUS DEFLEXUS, St. J. and W.

Pl. XXII, Fig. 1.

Fin spine of medium size, laterally compressed, moderately arched along the anterior edge, the posterior face relatively strongly concave, the spine uniformly expanding presenting a great breadth at the dorsal line, and indicating a very recumbent position. The lateral surfaces very gradually converge, with slight convexity, from the postero-lateral angles forward, where they are regularly rounded into the anterior edge; the posterior face, in the somewhat abraded specimen, is abruptly truncated, with indications of a low longitudinal keel, the angular lateral edges bearing a row of minute, vertically compressed denticles which are spaced by about their own diameter. The costation of the lateral surfaces is quite regular, the ridges regularly diminishing in size posteriorly, and simply convex, separated by a narrow impressed line, increasing by bifurcation which much more frequently occurs immediately along the dorsal line, beyond which the attenuated basal walls project in a narrow border from a point just above the inferior angle of the posterior face. The anterior edge is occupied by a comparatively wide ridge, which at intervals sends off lateral ridges. The entire exposed surface is densely crowded with the costal tubercles, which form irregular subconical prominences with vertically plicated or carinated sides, producing a stellate appearance, and which are even more crowded than represented in the full-size illustration. Along the worn anterior edge, where any remains of the costæ are visible, they have a pectinated appearance at their edges, in token of the tubercles originally ornamenting their crests. They are so crowded upon the costæ as to compel an alternate disposition; in the anterior portion they are crowded vertically, but over the greater portion of the surface they are spaced by about their own diameter. The pulp cavity is relatively large at the inferior angle of the posterior face, beneath which it first opens out, exposing the deep trough-like excavation extending thence to the proximal extremity, but rapidly diminishing above where it is filled by the peculiar deposition of dense matter analogous to the inferior homogeneous layer met with in the associated teeth of Cochliodonts, the 50 or 60 milimetres of the distal extremity being solid.

Mr. Butters has obtained from the St. Louis formation a single representative of the above described species, representing a spine 20 to 25 centimetres in length, of which the posterior face constituted half, little more or less. Unfortunately, the specimen was much mutilated in freeing it from the limestone matrix, both extremities being broken, and preserving a length of about 15 centimetres of the middle portion of the spine. It is a fine representative of a peculiar form of ichthyodorulite, of which several examples are known, and which is distinguished by the great fore and aft extent of the dorsal line and corresponding breadth of the inserted basal portion. In the foregoing description, allusion was made, in connection with the latter character, to the probable recumbent position the spine occupied in the creature's back; but this, after all, may not necessarily indicate unusual recumbency in view of the fact that, in certain living sharks, the integuments are built up about the bases of the spines, forming low, laterally compressed prominences from which their tips protrude, as is the case in *Cestracion.* We hesitate, however, in recognizing this feature as possessing generic importance in contradistinction to the narrow, more regularly and gradually tapering spines with which the latter have been generically associated.

The specific relations of the present specimen with previously described spines are perhaps most intimate with the Kinderhook species, *Ctenacanthus speciosus*, St. J. and W., and *C. spectabilis*, St. J. and W. Its distinguishing features, however, are so pronounced as not to require detailed comparison.

Geological position and locality: St. Louis limestone; Alton, Ill.

CTENACANTHUS HARRISONI, St. J. and W.

Pl. XXIII, Fig. 1.

The collection from the St. Louis formation contain an example of a large spine which is apparently intimately allied to the last preceding species, *Ctenacanthus deflexus*, but which presents certain well-marked peculiarities at variance with the distinctive features of that species. These differences do not appear to be such as might be attributable to age, and on the whole we are inclined to regard them as being of specific importance.

The specimen under consideration shows the greater part of a spine which probably attained a length of between 20 and 25 centimetres, and it apparently belonged to the broad-based type of which the preceding species constitutes a typical representative. Presenting about the same degree of curvature along the dorsal edge, it more gradually tapers, and the transverse section is less compressed laterally, approaching nearer a triangular outline than is the case in the former species, which, however, it resembles in the solid tip and comparatively limited extent of the closed pulp cavity. The specimen is much worn, but not sufficient to obliterate the limits of the dorsal line, the position of which is indicated by a symmetrical undulation in the abraded surface extending at a sharp angle backward and upward from the inferior dorsal angle; the posterior edges of the lateral walls are also evidently rounded by abrasion, so that it is difficult to make a satisfactory restoration of the outline of these edges that will accord with the known form of the corresponding portion of the species with which the present spine is especially compared. Along the dorsal edge, which is broadly rounded into the moderately convex sides, several rows of densely tuberculated costæ are still retained in a very perfect state of preservation, showing the transversely compressed tubercles with abrupt declivity above and steep slope below, delicately sculptured by vertical or radiating carinæ, the tubercles spaced by about their own diameter vertically and those of one row separated from the contiguous row by a mere line; over the remainder of the surface the costæ are obsolete. The posterior face is quite convex, with a low, rounded median angulation, and, in the specimen, sharply rounded into the lateral surfaces; there remains not a vestige of denticles along the postero-lateral angles. The posterior wall of the pulp cavity has been broken away,—it originally extended a distance of at least 7 or 8 centimetres from the tip before it opened out in the deep, trough-like excavation that extends thence to the proximal extremity.

As has already been remarked, the specimen described may prove to be specifically identical with that noticed under the head of *Ctenacanthus deflexus*. But this relationship can be satisfactorily determined only from the examination of additional materials, both forms being at the present time known from unique and imperfect examples. The specimen here referred to was obtained by Mr. George B. Harrison, of Bloomington, to whom we are also indebted for other interesting contributions.

Geological position and locality: St. Louis limestone; Alton, Illinois.

CTENACANTHUS PELLENSIS, St. J. and W.

Pl. XXI, Fig. 2

The collection of Mr. Van Horne contains a fragment of a medium-sized spine of a species not hitherto noticed. The specimen preserves a length of about 15 millimetres apparently from near the dorsal line, and from the high opening of the pulp cavity and other characters to be noticed further on, it would seem to belong to the section of Ctenacanthi characterized by the great extent of the dorsal line. The fragment indicates a thick, gradually tapering form, obtuse wedge-shaped in cross section, the posterior side deeply excavated by the open trough of the pulp cavity, which is defined by the beveled edges of the postero-lateral angles. Lateral surfaces gently convex, somewhat sharply arched into the rounded or subangular anterior edge. The surface ornamentation is very intricate and elegant, consisting of numerous delicate longitudinal costæ more or less regularly diminishing in size from the anterior edge, more frequently bifurcated and deflected on nearing the postero-lateral angles where they cease at the exterior beveled edge; in front the costæ present plain, rounded enameled crests spaced by narrower intervening sulci, their lateral edges studded with delicate downward curved transverse carinæ or tubercles; the third rib from the dorsal edge shows more or less distinct undulations, and the fifth rib is surmounted by small stellate tubercles more or less variable in the details of surface sculpture and disposition, their apices directed upward, and which apparently extend over the entire posterior flank of the lateral surfaces.

The spine under consideration is, perhaps, less intimately allied to *Ctenacanthus gemmatus*, St. J. and W., than with *C. deflexus* herein described, both from the same formation. In certain features of surface ornamentation it resembles the former, but in general form it is apparently allied to the latter; while in the details of ornamentation it possesses features readily distinguishing it from the described species of the genus. The fragment here alluded to is a rare acquisition at the locality where it was found, which has thus far afforded very few specimens of ichthyodorulites.

Geological position and locality: St. Louis formation, calcareous shales; Pella, Iowa.

CTENACANTHUS GRACILLIMUS, N. and W.

Pl. XXIV, Fig. 1.

Ctenacanthus gracillimus, NEWBERRY and WORTHEN, 1866, Ill. Geol. Survey, II, p. 126, Pl. XIII, f. 3.

Leptacanthus? occidentalis, NEWBERRY and WORTHEN, 1866, ib., II, p. 116, Pl. XII, f. 2.

Acondylacanthus occidentalis, ST. JOHN and WORTHEN, 1875, ib., VI, p. 433.

The above species is, perhaps, the most frequently met with of all the ichthyodorulites occurring in the St. Louis formation. The fine example now illustrated, and which was kindly loaned us for examination by Dr. George Hambach, belongs to the Shumard collection in Washington University at St. Louis, and is unquestionably the finest specimen of the species as yet discovered.

It is interesting to note the wide distribution of this ichthyodorulite. We have been favored with the loan of a specimen from equivalent deposits at Grand Rapids, Michigan, by Prof. E. A. Strong, which undoubtedly is identical with the present species.

The fin-spine originally described under the name *Leptacanthus? occidentalis*, N. and W., and subsequently referred by the authors to the genus *Acondylacanthus*, we are all but convinced is not specifically distinct from the above species. The latter spines are doubtless the worn upper portion of that species, in which the tuberculation of the anterior or dorsal keel and the first few lateral costæ are obsolete; the costæ themselves and the character of the posterior denticles are undistinguishable from that obtained in the two fine examples of *Ct. gracillimus*, above particularly referred to.

Geological position and localities: St. Louis formation; St. Louis, Missouri, Alton, Illinois, Grand Rapids, Michigan.

CTENACANTHUS CANNALIRATUS, St. J. and W.

Pl. XXI, Fig. 3.

Fin-spine long and slender, very gradually tapering, moderately arched along the dorsal edge, much compressed laterally, posteriorly truncated, wedge-shaped in transverse section, pulp cavity small, elongate oval in outline and confined within the posterior half of the diameter of the spine. Posterior face slightly depressed and traversed by a faint median keel, postero-lateral angles sharp, the slightly raised inner border showing indications of moderately spaced, minute, laterally compressed denticles. Lateral surfaces gently convex transversely and regularly converging toward the sharply rounded anterior edge, and occupied by more or less regularly rounded costæ, intercostal furrows deep, about half the breadth of the ridges. The posterior costæ are enveloped in a smooth enamel coating; toward the front they show delicate flexuous sharp-crested longitudinal lines, and the second or third rib from the dorsal ridge becomes distinctly interrupted by transverse carinæ, at the same time retaining the thread-like lines; the remaining ridges are more and more strongly marked by the transverse carinæ, the anterior one strongest of all. The carinæ cross the ribs obliquely, culminating above in delicate sharp crests, most prominent along the anterior margin where they are ornamented by a few sharp radiating lines producing a pectinated or notched appearance in that side; the anterior ridge is prominent, somewhat compressed laterally, and marked by similar slightly asymmetrical transverse ridges, which, however, are equally developed in either margin, producing a faint undulation along the rounded crest.

The collection of Dr. Hambach affords a small section of one of the long, slender spines of *Ctenacanthus* different from any form heretofore derived from the Chester formation. The spine is intimately related to *Ct. gracillimus*, N. and W., of the St. Louis limestone, for which indeed it might be mistaken on casual observation.

However, searching comparisons with the latter species discloses certain details in ornamentation which may indicate for the Chester form a specifically distinct, though closely allied, character. While the form and general appearance of the latter is strikingly like the St. Louis spine, there is a marked dissimilarity in the character of the costæ ridges or tubercles, which are very appreciably more regular and delicate than is the case in the St. Louis form. The magnificent example of the latter spine belonging to the Shumard collection of Washington University, affords unusually satisfactory details relating to the ornamentation of the exposed parts, also the changes in the superficial characters toward the distal extremity attributable to wear, the careful examination of which has led to the belief that the spine under consideration belonged to a distinct species.

Geological position and locality: Chester limestone; Chester, Illinois.

CTENACANTHUS BUTTERSI, St. J. and W.

Pl. XXII, Fig. 2.

Fin-spine of medium size, stout, slightly arched along the anterior edge, gradually tapering, subtriangular in cross section; the imbedded proximal extremity much more rapidly tapers, gently depressed below the anterior shoulder, relatively more expanded and triangular in section, the dorsal line making a broad curve, the concommitant plain space reaching high up toward the distal extremity even beyond the point of inclosure of the pulp cavity. The pulp cavity is inclosed posteriorly for only a comparatively short distance from the apex, where it opens out, forming thence a deep angular trench in posterior face reaching to the proximal extremity; its section approximates that of the external walls, its dimensions and position being shown in the section diagrams introduced with the illustrations of the type specimen. The posterior face appears to be slightly convex transversely and sharply rounded at the lateral angles, the specimens not showing denticles, if indeed such exist. The lateral surfaces are gently convex and more or less obtusely rounded along the anterior edge which bears a single longitudinal rib; the exposed surface is regularly and somewhat strongly ribbed, the costæ of moderate prominence and convexity, with narrow intercostal furrows, and chiefly bifurcating near the postero-lateral angles, where also short implanted costæ occur somewhat suddenly deflected to the narrow, plain belt bordering either posterior margin, along which they abruptly cease. The anterior ridges are interrupted by strong, crowded, transverse tubercles, which have a slight oblique direction backward and upward, the crest culminating above with gentler inferior slope, and delicately sculptured by radiating carinæ; the tubercles of the posterior ribs are similarly beautifully ornamented and distinguishable by their more oval transverse outline, relatively smaller size and acuminate crest which rises abruptly over the superior margins. The plain surfaces are striato-punctate longitudinally. The type specimen attains a length of 11.5 centimetres, the proportions as also the form being well represented in the illustrations.

The species above noticed is one of the handsomest of the genus. The specimen figured is the most perfect, but other fragments have been obtained indicating larger-sized spines equally strongly marked by the distinctive features of the species, and which readily distinguish it from any allied form known to us. In the deflected costæ along the posterior margins it bears some resemblance to *Ctenacanthus deflexus* of the St. Louis limestone, but is otherwise markedly distinct from that species, as will be apparent on comparing the illustrations given of each respectively. This is one of the many interesting discoveries of the remains of fishes in our Coal Measure strata made by Mr. Alexander Butters, in whose honor the specific name is given.

Geological position and locality: Lower Coal Measures (roof shales over coal No. 5, Illinois general section); Carlinville, Illinois.

GENUS ACONDYLACANTHUS, St. J. and W.

ACONDYLACANTHUS RECTUS, St. J. and W.

PL. XXVI, Fig. 2.

Dorsal ray of small size, slightly arched along the sharply-rounded anterior edge, moderately compressed laterally, and very gradually tapering throughout its length. Posterior face deeply grooved and traversed by a faint median keel, striato-punctate, and bordered by the relatively thick walls of the postero-lateral angles, which latter are rounded and bear close along their inner edge a row of comparatively strong, closely approximate, laterally compressed, downward-hooked denticles, which extend apparently from the apex (where they are worn obsolete) to the dorsal line, below which the pulp cavity issues. Lateral surfaces moderately convex transversely, rounded into the postero-lateral angle, and occupied by eight or more close, rounded costæ separated by narrow intercostal furrow, those in front bearing two rows of minute punctures and a faint median filiform line, the costæ enveloped in a smooth coating of enamel without transverse or tubercular elevation. Near the middle of the exposed right side of the type specimen, one of the costæ attains double the breadth of those in front, and immediately along the beveled posterior edges occurs a plain space apparently destitute of longitudinal ridges. Pulp cavity compressed ovate in outline, confined within the posterior half, and inclosed between thick walls. A specimen preserving a length of 65 millimetres has a breadth at base of 6.5 mm., and a thickness of 3 mm.

We have met with only a single example of the above described ichthyodorulite, which presents the greater portion of a small spine extending from the acute distal extremity to a point near the dorsal line, above which it is broken off. The specimen is cmbedded in a limestone matrix in such manner as to allow of the exposure of the right side and the posterior face; it is slightly distorted and fractured across at several places, revealing the small pulp-cavity, and somewhat worn especially along the posterior half of the lateral surfaces. The anterior costæ, however, are uninjured, and their condition is as noted above. The striking characteristics of the spine are its slight curvature, rigid outline, and the deeply channeled posterior face and closely set large denticles. The specimen has no near ally in the Coal Measure strata, and so far as it is possible to determine to the contrary, it presents all tho characteristics ascribable to *Acondylacanthus.*

Geological position and locality: Upper Coal Measures, above coal No. 9, Ill. Gen'l Sec.; the upper limestone at La Salle, Illinois.

ACONDYLACANTHUS NUPERUS, St. J. and W.

Pl. XXVI, Fig. 3.

Dorsal spine of medium size, rather strongly arched along the anterior edge and somewhat rapidly tapering, laterally compressed, transverse section cuneate; posterior face narrow, deeply channeled; pulp cavity relatively small, sublenticular or compressed ovoid in transverse outline. Lateral surfaces moderately convex transversely; sharply rounded into the anterior keel, also gently rounded and compressed posteriorly to the postero-lateral angles, which bear a row of laterally compressed, strongly downward-hooked denticles encircled at the base by a cincture, more or less regularly spaced by less than their own greater diameter, and extending two-thirds or more the length of the exposed portion of the posterior face. The lateral surfaces are occupied by more or less regular, prominent, rounded, smooth enamel-coated costæ separated by narrow intercostal furrows, the costæ comprised within the narrow compressed belt along the postero-lateral margins being more slender, and toward the base those occupying the body of the spine bifurcate, the anterior ridge especially sending off frequent slender branches to the dorsal line. The lower part of the spine shows distinct lines of growth exactly corresponding in curvature to the dorsal line and forming faint oblique annular ridges crossing the costæ at irregular intervals; otherwise the costæ are destitute of ornamentation, the occurrence of the oblique ridges mentioned not producing an effect comparable with that of the tuberculated Ctenacanthi. The dorsal line makes an angle of 40°, and less, with the anterior edge, somewhat sigmoidal in curvature, rising well up the postero-lateral angles; inserted base deep, surface irregularly striato-punctate. Length of spine 12 centimetres; greatest transverse breadth 13 milimetres.

The above described species is represented by a unique and nearly perfect specimen, which was discovered by Mr. A. S. Tiffany, to whom we are indebted for the opportunity to examine many interesting fish-remains from our Carboniferous and Devonian formations. In accordance with our understanding of the values to be ascribed to external characters in determining the limits of genera as represented by the fin-defenses of these early Selachians, the present spine does not reveal any feature markedly at variance with those ascribed to *Acondylacanthus*, with which we have identified it. Specifically, however, it offers tangible and most pronounced peculiarities, such indeed as may not readily escape notice even in fragmentary material, when sufficient remains to show its peculiar superficial features and the outline of its transverse section. Were it possible to decide the association of teeth and fin spines, we might in many instances find much less dissimilarity in the fin defenses of different genera than that indicated by their respective dentition. But lacking these facts relating to generic identity, we must seek to discover such characteristics as seem to have a common significance and by which these varied remains may be brought into such natural groups as appear most consistent with the features they possess in common.

Geological position and locality: Upper Coal Measures; upper limestone at Peru, Illinois.

ACONDYLACANTHUS? MUDGIANUS, St. J. and W.

Pl. XXIV, Fig. 3.

A fragment from the Upper Coal Measures of Kansas representing a medium-size ichthyodorulite is provisionally referred to the above genus. The specimen preserves a length of about 7 centimetres, apparently of the middle or lower portion of the spine, of which the entire anterior border is broken away, revealing the deeply excavated posterior face or the pulp cavity, bordered by a strip of the thick lateral walls near the postero-lateral angles. The transverse section of the spine is subtriangular, moderately arched along the anterior edge, lateral surfaces evidently gently convex transversely, and, so far as revealed by the remaining walls, ornamented by simple, angularly rounded longitudinal costæ, separated by deep, narrow intercostal grooves; the costæ enveloped in the smooth enamel layer throughout. Beyond this the superficial features are not disclosed, and so little remains that the moderately rapid tapering of the spine is hardly more than an inference.

While the generic relations of the specimen above referred to are by no means satisfactorily authenticated by the meagre characters that remain, its specific distinctness from any form occurring in the Coal Measures as yet discovered is unmistakable. The specific designation is given in honor of the late Professor Benjamin F. Mudge, the distinguished educationist and director of the first State geological survey of Kansas.

Geological position and locality: Upper Coal Measures; Rock Creek, Pottawattomie county, Kansas.

ACONDYLACANTHUS? XIPHIAS, St. J. and W.

Pl. XXVI, Fig. 1.

The unique example here referred to presents the larger portion of a large dorsal spine, probably between 20 and 23 centimetres in length, of which perhaps 5 centimetres of the distal extremity are broken short off, while the inserted portion shows evidences of curtailment in the rounded anterior margin. Besides, the surface of the exposed portion of the spine is evidently much worn, the costæ for the most part destitute of enamel, disclosing the irregularly pitted bony structure in common with that of the intercostal grooves, so that it is impossible to arrive at a satisfactory conclusion in regard to the character of the superficial ornamentation, upon which even depends the determination of the generic relation of the spine. Specifically, however, the specimen is clearly distinct from any form heretofore obtained from the same formation, and, judging from such of the superficial characters as are actually discernible, the spine might be provisionally identified with *Acondylacanthus.*

The spine gradually tapers, and is moderately arched along the anterior edge, the inclination making an angle of about 45° with line of insertion, lateral surfaces gently convex transversely, and very gradually converging toward the obtusely-rounded anterior edge, slightly compressed to the postero-lateral angles, the posterior wall broken away, exposing the oval-shaped pulp cavity lying within the posterior half of the spine. The exposed lateral surfaces of the spine are quite uniformly fluted longitudinally, the costæ presenting comparatively narrow rounded ridges, rarely bifurcating or implanted, and spaced by about their own width by the shallow intercostal grooves, the anterior edge apparently occupied by a wider ridge, vestiges of the usual enamel layer are discernible but not accompanied by visible nodose ornamentation. The base was deeply embedded in the integument, and channeled behind by the continuation of the pulp cavity. The spine preserves a length of 14 centimetres; the antero-posterior diameter, just above the dorsal line, 2.5 centim., which, however, does not represent the actual diameter on account of the imperfect condition of the posterior face; lateral diameter at same point, 9 millimetres.

The typical forms of *Acondylacanthus* are more slender, and proportionately narrower, than the above described form, and should the latter prove to possess nodose costæ, it should be transferred to the genus *Ctenacanthus.* But as has been already remarked, in the absence of any such ornamentation and the apparent smooth plain costæ, its affinities are clearly with the above genus.

Geological position and locality: Keokuk limestone; government canal excavations at Keokuk rapids, near Keokuk, Iowa.

Genus EUNEMACANTHUS,[1] St. J. and W.

Fin-spines arched backward, laterally compressed. Dorsal border rounded and occupied by a single plain, smooth ridge enameled throughout, and perhaps inbeveled along the lateral edges, which may be delicately sculptured. Lateral surfaces bearing longitudinal costæ interrupted by transverse ridges. Inter-costal furrows plain, or occupied by irregularly dispersed tubercles. Posterior face truncated, the lateral angles bearing a row of denticles whose apices are directed upward. Pulp cavity apparently inclosed throughout the greater length of the exposed portion of the spine.

The typical and sole representative of the genus here recognized, is the dorsal spine, originally described by Messrs. Newberry and Worthen, under the name *Ctenacanthus? costatus*, from the Saint Louis limestone. Allied to *Ctenacanthus*, the genus is especially characterized by the presence of the plain dorsal ridge, the tuberculated inter-costal sulci, and the upward direction of the denticles arming the angles of the posterior face. The interrupted character of the costæ of the lateral surfaces is precisely of the same nature so prevalent amongst though not restricted to the species of *Ctenacanthus*; the tuberculose inter-costal grooves and the direction of the apices of the posterior denticles recall a relationship with *Asteroptychius*, Agass., from which, however, it is distinguished by the transversely ridged and perhaps tuberculose character of the costæ.

Eunemacanthus costatus, (N. and W. sp.)

Pl. XXIII, Fig. 2.

Ctenacanthus? costatus, Newberry and Worthen, 1866. Ill. Geol. Surv., II. p. 120 Pl. XII, f. 5.

Spine of medium size, moderately arched along the dorsal edge and somewhat rapidly tapering, laterally compressed, presenting a wedge-shaped transverse section. The anterior or dorsal ridge arched transversely in about a quarter of a circle, lateral edges inbeveled and marked with delicate, sharp raised lines directed obliquely downward, the superior surface enveloped in a polished smooth enamel layer, occupying a space about equal to two of the adjacent lateral costæ. The latter irregularly diminished in size posteriorly, and are quite uniformly marked by slightly oblique transverse ridges slightly raised and culminating above in a low crest, the unworn slopes and depressions being beautifully sculptured logitudinally by delicate thread-like lines crossed by extremely fine transverse or oblique rugæ, the lateral edges similarly ornamented as noticed in the dorsal ridge; the nodose character of the transverse ridges increases toward the postero-lateral angles, however, retaining the details described, and in worn specimens the lateral costæ show more or less smooth crests, the extremities of the tubercles producing the pectinated or crenulated lateral borders observed in abraded specimens, like the original or type example of the species; the costæ increase by bifurcation and implantation below at frequent intervals. The intercostal sulci are perhaps one-half the diameter of the ribs, presenting a furrow of moderate depth, striato-punctate, that on either side of the dorsal ridge and others showing occasional irregularly dispersed tubercles ornamented precisely after the style observed in the costal tuberculations. Postero-lateral angles sharply defined, skirted by a narrow, faintly depressed outer belt of the posterior face, which rises into a low angular ridge defining the regularly transversely concave, moderately deep median furrow occupying more than half the lateral area, and which is coarsely pitted or striato-punctate; immediately along the outer side of the lateral crests occur a row of depressed, obovate, closely arranged tubercles, spaced by less than half their longer or longitudinal diameter, constricted basally and culminating in a low crest overhanging the upper border, similarly marked by delicate thread-like lines already remarked. The pulp cavity is of moderate capacity, compressed-oval in transverse section, and in an example of at least 150 millimetres in length it extends to within 20 mm. of the distal extremity, apparently opening out in the posterior face little if any above the dorsal line, which latter has a rather oblique upward course from the anterior dorsal angle, inserted base longitudinally striato-punctate, proportionately of considerable depth, perhaps equal to a fourth of the entire length of the spine.

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[1] *Eu*, beautiful; *nema*, line; *akantha*, spine.

The above description is founded upon two specimens: one, the original examined by Messrs. Newberry and Worthen, representing a small-size spine about 60 millimetres in length, showing one side with patches of the worn costæ and dorsal ridge which apparently terminate at the oblique dorsal line; the posterior face is broken away. The other specimen preserves nearly 111 millimetres of a spine, which probably attained a length of at least 150 mm., and though somewhat distorted by pressure, it presents in a very satisfactory manner the details of the surface ornamentation of a very handsome fin-defense, of which illustrations are given in the plate cited. Toward the tip in the older portions of the spine the lateral costæ are worn nearly smooth along their crests, though retaining vestiges of the transverse tuberculations in the pectinated lateral borders. Toward the base the costæ show uniformly less effects from wear, where the transverse ridges are beautifully preserved. But throughout its entire length the dorsal ridge presents the same uniform plain, smooth surface, an effect which it would seem inconsistent to attribute to abrasion. The specimen also clearly shows the form of the posterior denticles, as described, and which offer altogether an anomalous feature compared with the downward-hooked denticles occurring in the borders of the posterior face of typical *Ctenacanthus*.

Geological position and locality: St. Louis limestone: Alton, Illinois.

GENUS ASTEROPTYCHIUS, Agassiz.

ASTEROPTYCHIUS TENELLUS, St. J. and W.

Pl. XXI, Fig. 4.

Fin spine small, gradually tapering and moderately arched along the anterior edge, much compressed laterally, giving the transverse section a thin wedge-shaped outline, posterior face unknown. Lateral surfaces gently convex transversely, occupied by regular, delicate rounded costæ, intercostal furrows, increasing in width toward the anterior edge, the posterior furrows occupied by a single striato-punctate line, the middle and anterior ones showing two or more such lines separated by thread-like carinæ, the wide depression beside the anterior keel bearing several of these intercostal striæ and filiform ridges; the anterior keel, like the lateral costæ, is enveloped in a smooth enamel layer. The pulp cavity occupies about half the diameter of the spine, presenting an angular-ovate section, from which may be inferred the keeled condition of the posterior face.

The above species is represented by a fragment apparently belonging to the middle portion of a small delicate spine, which shows the anterior keel and the lateral surface nearly to the postero-lateral angles; but the posterior walls are broken away, exposing to view the pulp cavity, the carinate matrix of which would indicate perhaps, a rather prominent median angularity in the contour of the posterior face of the spine. Although we have no evidence of the denticles arming the postero-lateral angles, and even the wide furrow immediately adjacent the anterior keel is destitute of the characteristic tubercles, nevertheless the character of the striato punctate intercostal furrows, as also the general facies of the specimen, leave little room to doubt its generic identity with *Asteroptychius*. It is at the same time readily distinguished specifically by its extremely compressed, slender form, in which respects it presents marked contrast with the congeneric form *Asteroptychius bellulus*, St. J. and W., from the Lower Coal Measures.

Geological position and locality. Upper Coal Measures, calcareous shales overlying the coal at Topeka, Kansas.

GENUS GLYMMATACANTHUS, *St. J. and W.*

GLYMMATACANTHUS RUDIS, *St. J. and W.*

Pl. [illegible], Fig. [illegible]

Dorsal spine large, slightly [illegible] and somewhat rapidly tapering. Transverse section [illegible] meeting in the [illegible] crown. The lateral surfaces [illegible] angle of [illegible] [illegible] sharp impressed lines and [illegible] shaped, compressed [illegible] lines an exceedingly rough [illegible] angle of the spine [illegible] approximated [illegible] distinctly [illegible] postero-lateral [illegible] radiating [illegible] posterior [illegible]

[illegible]

important character, not so clearly discernible in the fragment of spine upon which the existence of the genus was based, of the backward curvature, which removes it from the Drepanacanthi, with which it bears some resemblance in the character and disposition of the longitudinal ribs and tubercles occupying the exposed parts. Unfortunately the entire section of the spine is not preserved, so that we are still uninformed in regard to the contour of the posterior face. Specifically allied to the Kinderhook *Glymmatacanthus Irishii*, St. J. and W., it is readily distinguished by the more rapidly tapering, smaller, transversely elongate, and much more prominent or conical tubercles, which are also more closely ranged along the costæ, and more widely spaced laterally than observed in the unique example of the earlier species just mentioned.

Geological position and locality: Keokuk limestone; Government canal excavations around the Keokuk rapids on the Mississippi, above Keokuk, Iowa.

GLYMMATACANTHUS PETRODOIDES, St. J. and W.

Pl. XXV. Fig. 2.

A mere fragment of an ichthyodorulite, hardly a centimetre square, in the collection of Dr. Hambach, is probably referable to the above genus. The superficial ornamentation is so well preserved as to enable very satisfactory comparisons with other species of the genus, as also to show its distinctive features so far as they depend on the character of the surface ornamentation. The fragment represents a bit from the lateral walls inclosing the pulp cavity, and probably pertained to a spine of medium size. The longitudinal costæ show only moderate convexity with the usual elongate irregular punctæ; closely arranged along their crests are rows of strong conical tubercles which crowd the surface, and which are deeply graven with sharp, strong carinæ, radiating from the apex and constricted at the base. The latter character, which, on account of the resemblance to the vertical plication of the cones of *Petrodus*, suggests the specific designation, also offers a marked and tangible contrast with the tubercular ornamentation observed in connection with the previously described species.

Geological position and locality: Chester limestone; Chester, Illinois.

GENUS GYRACANTHUS, Agassiz.

GYRACANTHUS? CORDATUS, St. J. and W.

Pl. XXVI. Fig. 4.

Spine of small size, very slightly arched along the anterior angle and gradually tapering, transversely triangular or cordate in section, Lateral surfaces broadly convex transversely, meeting in a narrow ridge forming an acute angle at the anterior edge; postero-lateral angles rounded and merging into the broad, moderately excavated posterior face. Exposed portion of the lateral surfaces ornamented with stellate tubercles closely set longitudinally, but showing a more or less distinct arrangement in oblique rows, with a forward and upward course. Pulp cavity relatively large, nearly circular in section, with a thin wall in the axis of the posterior face and thickened at the lateral angles, opening below in a deep furrow extending to the proximal extremity.

The description is based upon a [illegible] about 5.5 centimetres of the length of a [illegible] ities have been broken away and [illegible] ured by abrasion, [illegible] features indistinct over the greater part of [illegible] which appears to be [illegible] ever, these latter [illegible] teristic, or at least [illegible] with the contour of the posterior face [illegible] to that genus. [illegible] the tubercles are [illegible] obliquity is even more [illegible] to that [illegible] ance of irregular [illegible] marked [illegible] to *Gyracanthus* [illegible] latter genus [illegible] without [illegible] and [illegible] [illegible] pressed [illegible] spa[illegible] where, as already noted, they appear to have the oblique arrangement common to the genus to which the species represented by the above specimen is provisionally referred, and of which it is, at the present time, the sole representative from the Carboniferous formations of the Upper Mississippi region. Principal Dawson has noticed representatives of the genus from the Carboniferous of Nova Scotia, and Dr. Newberry has described some interesting species from the Lower Carboniferous of Ohio.

Geological position and locality: Keokuk limestone; Keokuk, Iowa.

GENUS PHYSONEMUS, Agassiz.

PHYSONEMUS FALCATUS, St. J. and W.

PL. XXIV, FIG. 6.

Dorsal spine of small size, comparatively narrow, gradually tapering, and very strongly arched along the posterior face, the tip reaching a point nearly vertical to the inferior extremity. Transverse section wedge-shaped, anterior edge making an acutely rounded angle, expanding below into the inferior shoulder, which is sharply constricted at the dorsal line to the plain base. Lateral surfaces slightly convex, the bony surface showing an impressed line parallel with the posterior edge as usually observed under similar conditions of surface exfoliation.

The description refers to a unique example belonging to the collection of Washington University. It represents nearly the entire outline, but as so frequently occurs with the small specimens of the genus, the posterior face is worn away, the pulp cavity making a groove throughout its exposed extent. The exposed portion of the spine, also, is denuded of the original longitudinal costæ and tuberculation, of which not a vestige remains from which to infer the character of the superficial ornamentation. The strong curvature of the spine recalls the forms to which the names *Physonemus parvulus*, and *Ph. Cestriensis*, derived respectively from the Keokuk and Chester formations, have been given. It is, however, a much more slender form, not attaining near the breadth of the above named spines. It is, indeed, possible that it prove to be a young individual of the species *Ph. Altonensis*, St. J. and W., of the same formation, though the latter identity seems highly improbable.

Geological position and locality: St. Louis limestone; St. Louis, Missouri.

GENUS DREPANACANTHUS, N. and W.

DREPANACANTHUS REVERSUS, St. J. and W.

Pl. XXIV, Fig 5.

Drepanacanthus reversus, ST. JOHN and WORTHEN, 1875. Ill. Geol. Surv., VI, p. 4[illegible], Pl. XIX., f. 5, 6.

A nearly perfect specimen of the above named species has lately been obtained at Alton. The specimen shows nearly the complete outline, but it is, unfortunately, too abraded to distinctly display the ornamentation, which was very clearly made out from the fragments upon which the original description was based. The specimen here referred to is reproduced in the illustrations. With the exception of the tip and the extreme end of the base, it is perfect, and is readily distinguished from the Keokuk species previously described by its stronger curvature, while the tuberculation is quite different, as has been already pointed out.

Geological position and localities: St. Louis limestone, Alton, Illinois, and St. Louis, Missouri.

GENUS BATACANTHUS [illegible]

[illegible]

[illegible]

The [illegible]
example [illegible]
extremity [illegible]
suggested [illegible]
as [illegible]
Drepanacanthus [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] species [illegible]

GENUS ORACANTHUS, Agassiz.

ORACANTHUS VETUSTUS, Leidy.

Pl. XXIV. Fig. 2.

Oracanthus vetustus, LEIDY, 1856. Jour. Acad. Nat. Sci., Phila., 2d series, III. p. 161, Pl. 16, f. 1, 2, 3.
Oracanthus consimilis, St.J. and W., 1875. Ill. Geol. Surv. VI, p. 476, Pl. XXII, f. 15.

The cabinet of Washington University, of St. Louis, contains a fine large spine, which, we have no doubt, is specifically identical with the form originally described by Dr. Leidy under the above designation, and which was subsequently noticed by the authors under the name *Oracanthus consimilis*. This specimen, however, affords a much more satisfactory idea of the superficial characteristics of the spine than it was possible to gain from the fragmentary material accessible to us at the time the latter notice was prepared, and we are thankful for the opportunity of correcting and extending the notice of the species, which we owe to Dr. Hambach, of that institution, and to Dr. Leidy, who kindly secured the loan of the type specimen from the museum of the Academy of Natural Science.

The above mentioned specimen preserves a length of 15 centimetres, and a width of above 6 c. m., the basal margin and a portion of the left side being broken away, exposing the large pulp cavity. The outline is that of a moderately backward-curved, rapidly tapering laterally-compressed cone, terminating in a sharp point, the [illegible] edge broadly and regularly rounded into the gently [illegible] surfaces; the concave posterior border somewhat [illegible] sharply rounded, but without defined [illegible] walls of the pulp cavity are moderately [illegible] est thickness along the convex anterior [illegible] or less crushed in by pressure. The exposed [illegible] show obscure, irregular longitudinal [illegible] with tubercles, which assume a variety of [illegible] position, and ranged in [illegible] verse rows, which, in the right side, [illegible] ward and backward [illegible] similar rows [illegible] direction; but toward the [illegible] and larger, this [illegible] tudinal disposition is more or less [illegible] with the latter interpretation of their relative position, or in pairs at the lateral line. We are, however, not sufficiently familiar with the species of the genus to be able to decide to what extent this asymmetrical character may be relied upon or whether it is persistent alike in all representatives of the genus. *Oracanthus* has already been compared with the dermal scutes of the Rays, and a rather heterogeneous variety of forms have been generically identified. In some particulars, as the oblique course of the tuberculation, they recall a resemblance to the Gyracanthi, but no vestige exists of the strong implanted base accompanying *Gyracanthus*, while their general proportions and outline are widely different. Neither are we prepared to affirm relationship with forms of teeth occurring in the same deposits, although their supposed affinities naturally suggest possible relations with *Psammodus*.

Geological position and localities: St. Louis limestone; St. Louis, Mo., Alton, Ill., Pella, Iowa, &c.

ORACANTHUS RECTUS, St. J. and W.

Pl. XXV, Fig. 3.

Dr. Hamback has obtained from the Chester formation a mere fragment of a spine, showing a narrow section of what appears to have formed part of the dorsal or anterior edge, which certainly possesses congeneric relations with the fossils from the Keokuk limestone, to which we gave the name *Oracanthus ? obliquus* (Ill. Geol. Surv., VI, p. 477, Pl. 12, f. 16), although they are respectively distinguished by well-marked specific characters.

The Chester specimen shows a spine with a very obtusely angular, nearly straight anterior (?) edge, the lateral surfaces diverging at a moderate angle therefrom, and studded with rudely sculptured, irregular-shaped conical tubercles, ranged in closely approximated vertical lines and more or less regular oblique rows, on the left side rising from left to right; along the anterior ridge the tubercles become transversely elongated, showing the same strong radiating plicæ and wide vertical spacing; the right side preserves a few small, scattered tubercles, belonging to two or three rows, and which appear to form oblique rows ascending in the opposite direction to that observed in the left side. The tubercles present a more abrupt slope above, and at one part of the fragment they appear to become confluent along one of the lateral costæ, forming an irregular, agged crest; their worn apices show distinct punctate structure, intimately resembling the eroded coronal surfaces of *Orodus* and other teeth occurring in these deposits, the intertubercular spaces showing the ordinary striato-punctate markings of ichthyodorulites. The fragment does not reveal the thickness of the walls nor any part of the pulp cavity; it evidently belonged to a medium-size spine.

Compared with *Oracanthus obliquus* of the Keokuk limestone, the present form is distinguished by its more rigid outline and the more regular distribution of the tubercles. In both forms the oblique transversely elongate tubercles are asymmetrical; in other words, the crest culminates in a submedian apex along the angularly rounded border, from which the longer lateral crest declines obliquely upward and backward in the Keokuk spine on the right side of the anterior angle, and in the present form on the left side of the less angularly rounded anterior border. We are, however, inclined to regard the unique example of the Keokuk species as pertaining to the anterior edge of the spine, and the Chester form here alluded to as possibly belonging to the opposite or posterior edge. Examined in the relative positions thus indicated, the direction of the obliquity of the transverse rows of tubercles in the unique representatives of the species mentioned, merely indicate the opposed positions of the respective fragments, in both of which the oblique transverse disposition of the tubercles is essentially the same. If the relative position of the fragment of the present spine is correctly inferred, it differs from the form occurring in the St. Louis limestone, *O. vetustus*, Leidy, in the much less marked obliquity of the transversly elongate tubercles near the anterior border, in which latter respect, however, the latter species shows variations approaching the condition observed in the present spine. But the relations of these spines can only be determined from the examination of more complete and better preserved individuals in the case of the present species and that from the Keokuk formation.

Geological position and locality: Chester limestone; Chester, Illinois.

GENUS PNIGEACANTHUS, St. J. and W.

PNIGEACANTHUS TRIGONALIS, St. J. and W.

Pl. XXIV, Fig. 4.

Dormal defense as seen from the side trigonal in outline, laterally much compressed, walls thin, terminating in an obtuse apex projecting backward about 10° past a point vertical to the postero-inferior angle, exceedingly attenuated inferiorly with signs of a plain marginal border that was buried in the integument. Anterior edge gently arched, slightly curved toward the inferior angle, rounded into the gently convex lateral surfaces; posterior border apparently a little more compressed, gently concave vertically, and studded with relatively strong, irregular, rudely sculptured tubercles. The anterior border is armed with large irregular vertically elongate depressed tubercles, which seem to lie immediately on the left flank of the border, forming a nearly continuous undulating ridge. The tubercles, so far as may be determined by the specimen, are markedly asymmetrical, the slope facing the anterior edge being abrupt and obscurely vertically sculptured, the opposite side presenting a wider gentle declivity. The lateral surfaces show more or less distinct longitudinal costæ, irregularly striato-punctate, and studded with irregular stellate tubercles whose apices are directed upward; the tubercles, as seen in the left side, vary in size and present a rude sort of transverse disposition, especially toward the anterior border where occasional large tubercles occur, but irregularly dispersed as relates to the longitudinal costæ. The inner surface of the lateral walls is smooth with a fine wavy striato-punctate structure. The spine may not show the perfect outline of the inferior margin, but the preserved portion in the flattened condition of the specimen measures about 25 millimetres from the antero to the postero-inferior angle; height of posterior border, 20 mm.; ditto of anterior border at least 33 mm.

The collection of Mr. Alexander Butters contains the unique and nearly entire example upon which the above description is based. The specimen is embedded in a limestone matrix in such manner as to reveal only the one side, and part of this is broken away exposing a corresponding area of the inner side of the opposite wall, the thin inferior portions of the walls being brought into close contact by pressure. The specimen is unquestionably closely allied to the Keokuk form, *Pnigeacanthus pnigeus* [1] (N. and W., sp.), from which it is distinguished by its somewhat stouter proportions, less deeply concave posterior border, and the peculiar tuberculation of the borders. The general character of the tuberculation of the lateral surfaces is much the same in both forms, but in the present one the tubercles are relatively smaller and less crowded.

Geological position and locality: St. Louis limestone; Alton, Illinois.

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[1] We are under obligations to S. A. Miller, Esq., for reminding us of our remissness in needlessly adding to the already burdensome complications of nomenclature, which we perpetrated in abandoning the original specific designation applied to this fossil when we transferred it to a distinct genus, of which it is the type.

SYSTEMATIC AND CHRONOLOGICAL LIST

OF FOSSIL FISHES DESCRIBED IN THE PRESENT VOLUME.

COCHLIODONTIDÆ, OWEN.

	Page.
PSEPHODUS, Agassiz, - - - - - - - - - -	62
— *obliquus*, St. J. and W., Kinderdook, - - -	66
— *placenta*, (N. and W. sp.), Kinderhook, - - -	69
— *symmetricus*, St. J. and W., Kinderhook, - -	71
— *latus*, St. J. and W., St. Louis, - - - -	72
— *lunulatus*, St. J. and W., Chester, - - -	74
TÆNIODUS, L. de Koninck, - - - - - - - - -	75
— *fasciatus?* (N. and W. sp.) Keokuk, Warsaw, St. Louis,	76
— *regularis*, St. J. and W., Warsaw, - - - -	77
— *obliquus*, St. J. and W., Chester, - - - - -	78
VATICINODUS, St. John and Worthen, - - - - - -	80
— *vetustus*, St. J. and W., Kinderhook, - - -	82
— *discrepans*, St. J. and W. Upper Burlington, - -	83
— *? simplex*, St. J. and W., St. Louis, - - -	84
— *? similis*, St. J. and W., Chester, - - - -	86
— *? carbonarius*, St. J. and W., Coal Measures, - -	88
— *? lepis*, St. J. and W., U. Coal Measures, - - -	88
DELTOPTYCHIUS, Agassiz, - - - - - - -	89
— *primus*, St. J. and W., Upper Burlington, - -	93
— *Wachsmuthi*, St. J. and W., Keokuk, - - -	93
— *Varsoviensis*, St. J. and W., Warsaw, - - -	96
— *expansus*, St. J. and W., St. Louis, - - -	98
— *nitidus*, (Leidy sp.), Chester, - - - - -	99

Page.
Stenopterodus, St. John and Worthen, 100
— *planus*, St. J. and W., Upper Burlington, 102
— sp. undet., Keokuk, 105
— *elongatus*, St. J. and W., Warsaw, 106
— *parvulus*, (N. and W. sp.), St. Louis, 107
Chitonodus, St. John and Worthen, 109
— *Springeri*, St. J. and W., Upper Burlington, 112
— *antiquus*, St. J. and W., Lower Burlington, 116
— *tribulis*, St. J. and W., Keokuk, 117
— *liratus*, St. J. and W., St. Louis, 119
Cochliodus, Agassiz, 120
— *Van Hornii*, St. J. and W., St. Louis, 120
— *obliquus*, St. J. and W., St. Louis, 126
— *Leidyi*, St. J. and W., Chester, 127
— *? bialveatus*, St. J. and W., Upper Burlington, 169
— *? Keokuk*, St. J. and W., Keokuk, 169
— *? convexus*, St. J. and W., U. B. and Keokuk, 169
Tomodus, Agassiz, 171
— *? limitaris*, St. J. and W., Upper Burlington, 173
Xystrodus, Agassiz, 175
— *simplex*, St. J. and W., Upper Burlington, 178
— *inconditus*, St. J. and W., Keokuk, 179
— *imitatus*, St. J. and W., St. Louis, 180
— *verus*, St. J. and W., Chester, 181
— *bellulus*, St. J. and W., Coal Measures, 183
Sandalodus, Newberry and Worthen, 184
— *complanatus*, (N. and W. sp.), Upper Burlington, 184
— *lævissimus*, N. and W., Keokuk, 186
— sp.? Warsaw, 187
— *spatulatus*, N. and W., St. Louis, 188
Orthopleurodus, St. J. and W., 190
— *carbonarius*, (N. and W. sp.), Coal Measures, 192
— *convexus*, St. J. and W., Coal Measures, 193
— *Novo Mexicanus*, St. J. and W., Lower Carb., 195
Pœcilodus, Agassiz, 131
— *Varsoviensis*, St. J. and W., Warsaw, 131
— *St. Ludovici*, St. J. and W., St. Louis, 132
— *Cestriensis*, St. J. and W., Chester, 135
— *Wortheni*, St. J., Chester, 136
— *Springeri*, St. J. and W., L. Carboniferous, 138
— *carbonarius*, St. J. and W., Coal Measures, 139

PAGE.
Deltodus, Agassiz, - - - - - - - - - - - - 141
— *latior*, St. J. and W., Keokuk, - - - - - 145
— *cinctulus*, St. J. and W., Warsaw, - - - - - 146
— *trilobus*, St. J. and W., Warsaw, - - - - - 148
— *occidentalis*, (Leidy sp.), Keokuk, - - - - - 150
— *parvus*, St. J. and W., St. Louis, - - - - - 151
— *intermedius*, St. J. and W., St. Louis, - - - 153
— *Powellii*, St. J. and W., Upper Carboniferous, - 154
— *propinquus*, St. J. and W., Coal Measures, - - 156
Deltodopsis, St. John and Worthen, - - - - - - 158
— *affinis*, St. J. and W., Warsaw, - - - - - - 160
— *St. Ludovici*, St. J. and W., St. Louis, - - - 161
— *angustus*, (N. and W. sp.), Chester, - - - - 163
— *? convolutus*, St. J. and W., Upper Burlington, - 165
— *? inflexus*, St. J. and W., Keokuk, - - - - - 167
— *? exornatus*, St. J. and W., Warsaw, - - - 168

PSAMMODONTIDÆ, L. de Koninck.

Psammodus, Agassiz, - - - - - - - - - - 197
— *Springeri*, St. J. and W., Upper Burlington, - - 202
— *tumidus*, St. J. and W., Upper Burlington, - - 205
— *turgidus*, St. J. and W., Upper Burlington, - - 206
— *Lovianus*, St. J. and W., L. and U. Burlington, - 207
— *glyptus*, St. J. and W., Upper Burlington, - - 209
— *grandis*, St. J. and W., Keokuk, - - - - - 211
— *plenus*, St. J. and W., St. Louis, - - - - - 213
— *cælatus*, St. J. and W., St. Louis, - - - - 217
— *crassidens*, St. J. and W., St. Louis, - - - 218
— *angularis*, N. and W.. Chester, - - - - - 222
— *reticulatus*, N. and W., Chester, - - - - - 224
Copodus, Agassiz, - - - - - - - - - - - - 227
— *Van Hornii*, St. J. and W., St. Louis, - - - 229
— *pusillus*, St. J. and W., Chester, - - - - 231

ICHTHYODORULITES.

PAGE.
CTENACANTHUS, Agassiz, - - - - - - - - - - 233
— *Coxianus*, St. J. and W., Keokuk, - - - - 233
— *deflexus*. St. J. and W., St. Louis, - - - - - 234
— *Harrisoni*, St. J. and W., St. Louis, - - - - 236
— *Pellensis*. St. J. and W., St. Louis, - - - - - 237
— *gracillimus*, N. and W., St. Louis, - - - - 238
— *cannaliratus*. St. J. and W., Chester, - - - - 239
— *Buttersi*. St. J, and W., Coal Measures, - - - 240
ACONDYLACANTHUS, St. John and Worthen, - - - - - 241
— *rectus*, St. J. and W., U. Coal Measures, - - - 241
— *nuperus*, St. J. and W., Coal Measures, - - - - 242
— ? *Mudgianus*, St. J. and W., Coal Measures, - - 244
— ? *xiphias*, St. J. and W., Keokuk, - - - - - 244
EUNEMACANTHUS, St. John and Worthen, - - - - - 246
— *costatus*, (N. and W. sp.), St. Louis, - - - - 246
ASTEROPTYCHIUS, Agassiz, - - - - - - - - - 248
— *tenellus*, St. J. and W., U. Coal Measures, - - - 248
GLYMMATACANTHUS, St. John and Worthen, - - - - - 249
— *rudis*, St. J. and W., Keokuk, - - - - - - 249
— *petrodoides*, St. J. and W., Chester, - - - - 250
GYRACANTHUS, Agassiz, - - - - - - - - - - 251
— ? *cordatus*, St. J. and W., Keokuk, - - - - 251
PHYSONEMUS, Agassiz, - - - - - - - - - - 252
— *falcatus*, St. J. and W., St. Louis, - - - - 252
DREPANACANTHUS, Newberry and Worthen, - - - - - 253
— *reversus*, St. J. and W., St. Louis, - - - - - 253
BATACANTHUS, St. John and Worthen, - - - - - - 253
— ? *necis*, St. J. and W., Keokuk, - - - - - 253
ORACANTHUS, Agassiz, - - - - - - - - - - 255
— *vetustus*, Leidy, St. Louis, - - - - - - 255
— *rectus*, St. J. and W., Chester, - - - - - - 257
PNIGEACANTHUS, St. John and Worthen, - - - - - 259
— *trigonalis*, St. J. and W., St. Louis, - - - 259

PALÆONTOLOGY OF ILLINOIS.

SECTION II.

DESCRIPTION OF FOSSIL INVERTEBRATES.

BY A. H. WORTHEN
AND
A. H. WORTHEN AND S. A. MILLER.

INTRODUCTORY REMARKS.

For the use of several of the crinoids described and figured in this volume, I am indebted to the liberality of Mr. L. A. Cox, of Keokuk, Iowa, who, by his zeal and indefatigable industry as a collector, has brought together one of the finest collections of these beautiful fossils ever obtained from the Keokuk limestone, and a part of them were found in a higher position in the Keokuk group than that from which this class of fossils has usually been obtained. These came from a sandy stratum only a few inches in thickness, situated near the dividing line between the geodiferous shales of the Keokuk group and the overlying Warsaw beds, which form the upper part of the river bluff about a mile below the steamboat landing, where the fossils were obtained.

Another very interesting and productive locality was found by Mr. N. K. Burket, of Keokuk, in the Keokuk limestone at Hamilton, Illinois, and from this a part of the following species were obtained. These came from a cherty layer some three or four inches in thickness, intercalated near the top of the quarry rock at Hamilton, some five or six feet below the base of the geodiferous shales. These two very limited horizons have furnished all the Keokuk species, with one or two exceptions, that are described and illustrated in the following pages.

The species from the St. Louis and Chester groups were all collected by the author, and form a part of the Illinois State Collection.

A. H. W.

PALÆOCRINOIDEA.

GENUS POTERIOCRINUS, Miller.

POTERIOCRINUS COXANUS, Worthen.

Pl. XXVII. Fig. 1.

Poteriocrinus Coxanus, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 4.

Body above the medium size, obconic, gradually swelling from a truncated base to the summit of the radial plates, where it is about one-fourth wider than high. Basal plates as wide, or a little wider, than high, forming by themselves a low pentagonal cup, about twice as wide as high. One subradial on the anterior side is longer than wide, the others about as wide as long, all pentagonal, there being but two distinct angles on their lower margins.

Radials nearly once and a half as wide as high on the anterior rays, curving in on their lateral borders so as to give a pentalobate character to the upper part of the body.

Brachials two, the first quadrangular, and the second pentangular, and both more than twice as wide as long, the second supporting on their sloping sides the first divisions of the rays. Only two of the rays and a part of the third are to be seen, the others being concealed in the rock. In one of these, probably the anterior ray, a second bifurcation takes place on the fifth plate in each division, and the outer branch is seen to divide once more about the tenth plate, and the inner division on the twenty-fourth to the twenty-sixth plate, beyond which the arms of this ray are not preserved.

On the right antero-lateral ray the second bifurcation takes place on the fourth plate in each division, the outer branch dividing twice more on the eighth and twenty-second plate, and the inner one twice on the twenty-fourth to the twenty-sixth plate, beyond which they are not preserved. This gives twelve visible arms to this ray, and it is quite possible there were other divisions beyond, as the arms extended about two inches beyond the last divisions that are preserved. The arms are stout, and composed of rounded, short, nearly parallel plates, that give off delicate pinnules from their inner margins. The uppper part of the ventral tube is exposed by the partial removal of the arms, showing that this organ was trumpet-shaped, and crowned with heavy hexagonal plates, produced at the center into rather sharp nodes, while below the plates are thinner, and crossed by about three sharp ridges, that are most prominent in the center of the plate. Similar ridges are also visible on the margins of some of the summit plates. Anal plates unknown. Column round and rather stout, composed of thin, even plates. Length of body and arms 5⅝ inches, breadth at the summit of the ventral tube 2¾ inches, length of column 7⅝ inches.

This magnificent specimen of *Poteriocrinus*, the finest ever obtained from the Keokuk limestone, I take pleasure in dedicating to Mr. L. A. Cox, of Keokuk, Iowa, to whom it belongs, in recognition of his zeal and untiring industry in collecting the crinoids and fishes of that vicinity.

Position and locality: Upper part of the Keokuk limestone, Hamilton, Ill.

Mr. L. A. Cox's collection.

POTERIOCRINUS BURKETI, Worthen.

Pl. XXVIII, Fig. 8.

Poteriocrinus Burketi, WORTHEN, February, 1882.

Bulletin No. 1, of the Illinois State Museum of Natural History, p. 5.

Body small, cup-shaped below the summit of the first radial plates. Basals small and concealed by the first joints of the column. Subradial plates slightly protuberant from the depression of their upper angles, curving below into the basal concavity.

Radials pentagonal, about once and a half as wide as long. Brachials two to each ray, the first quadrangular, and the second the same form as the radials, and supporting on their upper, sloping sides the first division of the arms. The arms after the first division on the second brachial plate, divide again on the sixth to the ninth plate, beyond which they continue simple to their extremities, making four arms to each ray. Arms composed of slightly wedge-formed plates, about as long as wide below the last bifurcation, but proportionately longer and more zigzag in their arrangement above, giving off strong pinnules alternately from their longest sides. Anal plates small, the first one apparently resting between two of the subradials, and this is succeeded by a double series of minute plates that form the lower extremity of the ventral tube. This organ is composed of minute plates, is balloon shaped, and shows a small opening about two-thirds the distance from the base to the summit. Column at the top composed of round, nearly uniform plates, but a short distance below thicker joints are intercalated at irregular intervals. It decreases in diameter nearly one-half in a distance of two inches from the top, and has delicate cyrrhi attached on either side at irregular intervals.

The depressions at the angles of the body plates, give to the exterior of the cup-shaped body a somewhat rough appearance.

This species is named in honor of Mr. N. K. Burket, of Keokuk, Iowa, who discovered the interesting locality at Hamilton where this and several other new forms have been obtained.

Position and locality: Top of the Keokuk limestone, Hamilton, Illinois.

Nos. 260 and 402 of Mr. L. A. Cox's collection.

POTERIOCRINUS TENUIDACTYLUS, Worthen.

Pl. XXVIII, Fig. 13.

Poteriocrinus tenuidactylus, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 6.

Body obconical, length and breadth to the top of the radial plates about equal. Basals well developed, expanding upward from the column, forming a pentagonal cup rather wider than long. Subradials about as wide as high, the one on the posterior side supporting in part two quadrangular anal plates, that are succeeded by a double series of smaller plates of the same form, forming the base of the ventral tube.

Radials pentagonal, wider than high. Brachials four to each of the posterior rays, three of them quadrangular and the fourth pentangular, supporting on its upper sloping sides the first divisions of the rays. The arms in the left posterior ray, after dividing on the last brachial, give off a branch from each division, about the twelfth to the twentieth plate, beyond which they are simple as far as can be seen, giving four arms to this ray.

The arms are long and slender, composed of rather long, rounded joints, slightly zigzag in their arrangement, and give off rounded pinnules from their projecting sides.

The ventral tube, of which some traces can be seen an inch above the base, appears to have been cylindrical, starting with the two long quadrangular anal plates that rest on the posterior subradial plate, the succeeding plates decreasing upward in size.

Column at its upper extremity rather large, and composed of extremely short joints, closely ancyhlosed together.

Position and locality: Upper part of the geode bed, one mile below Keokuk.

No. 202 of Mr. L. A. Cox's collection.

POTERIOCRINUS IOWENSIS, Worthen.

Poteriocrinus Iowensis, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 6.

Body short, about once and a half as wide as high. Basal plates small and hidden by the first columnar joints. Subradials small, slightly protuberant at the center and depressed at the angles. Radials twice as wide as long, pentagonal, depressed on their lower lateral borders, with a tolerably well defined suture between them and the brachials.

Brachials two, the first quadrangular, twice as wide as long, the second pentagonal, giving support on their sloping angles to the first divisions of the rays, and slightly protuberant at their upper angles.

Arms after the first division on the second brachial in two of the rays, the left posterior and right antero-lateral rays divide again on the fifth to the seventh plate, beyond which they are simple as far as they have been preserved. On another ray, which may be the anterior one, the first bifurcation takes place apparently on the fifth brachial, and the second one on the third plate above, as near as can be determined from the crushed condition of this ray. Anal plates unknown.

Column round, composed of rather thick joints near the body, becoming alternately thinner below.

This species is related to *Pot.* (*Scaph.*) *Gibsoni* of White, but differs from it in the number and mode of bifurcation of the arms, and also in the form and proportion of the plates composing the body.

Position and locality: Upper shales of the geode bed, one mile below Keokuk, Iowa.

No. 56 of Mr. L. A. Cox's collection.

From an oversight this specimen was not figured.

POTERIOCRINUS HAMILTONENSIS, Worthen.

Pl. XXVII. Fig. 9.

Poteriocrinus Hamiltonensis, WORTHEN. Feb. 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 7.

Body short, forming a low, shallow cup about twice as wide as high. Base concave, the basal plates being hidden by the first columnar joints. Subradials of nearly uniform size, four hexagonal and one heptagonal, all curving below into the basal concavity. Radials, four of them nearly twice as wide as long, pentagonal, the one on the anterior side smaller, and all indented at their lower angles to correspond with the similar indentations of the upper angles of the subradials. A somewhat gaping suture exists between the radial and brachial series. Brachials, one to each ray, longer than the radials, and four of them sharply angular above for the support of the arms. On the anterior ray the brachial is constricted above to about one-half its width below, and on its upper truncated margin supports the plates of a single arm, making nine arms altogether for this species. Four or five anal plates can be seen arranged as usual in this genus. Arms composed of short quadrangular plates, that give off strong pinnules, the joints of which are twice or more as long as wide. Column, unknown.

This species is nearly related to the little form to which we have given the name *P. penicilliformis*, but differs from that in its more broadly cup-shaped body, shorter brachials and arm-plates, and also in the pit-like depressions at the angles of the body-plates. The body alone could not be easily distinguished from *Pot.* (*Scaph.*) *unicus* of Hall, while it is entirely unlike that in the number and arrangement of the arms.

Geological position and locality: Upper part of the Keokuk limestone, Hamilton, Illinois.

No. 176, Mr. L. A. Cox's collection.

POTERIOCRINUS ORESTES, Worthen.

Pl. XXVII. Fig. 3.

Poteriocrinus Orestes, WORTHEN. Feb. 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 7.

Body depressed, cup-shaped, about twice as wide as high. Base concave, basals small and concealed under the first columnar joints. Subradials as wide or a little wider than high, three hexagonal and two on the posterior side heptagonal, all curving into the cavity below. Radials about twice as large as the smaller subradials, four of them pentagonal, and one on the right posterior side heptagonal, counting three angles below.

Brachials, five to the anterior ray, the first one of which is as wide below as the first radial, but constricted above to correspond with the narrow, succeeding plates, which are quadrangular and narrowly rounded on their external surfaces. The fifth brachial is angular above, a little wider than those below, and gives support on its upper sloping sides to the first divisions of the ray, which thence continue simple to their extremities.

The four other radials have each a single brachial, which is as wide as the radial on which it rests, with a gaping suture between, all pentangular, and supporting on their sloping upper angles the first divisions of the rays.

The left antero-lateral ray, after its first bifurcation on the brachial plate, divides again on the sixth plate above, and the outer division twice more on the seventh or eighth plate, while in the right antero-lateral both divisions bifurcate on the sixth plate, and the outer division again on the seventh or eighth plate, making five divisions to this ray, which is probably the normal number in all the rays except the anterior one, or twenty-two in the complete organism. The arms are composed of rounded, wedge-formed joints, giving off strong pinnules alternately from their longest sides; pinnules composed of rounded joints about twice as long as wide.

Anal plates, five visible. The first one is pentagonal, and rests between the upper angles of the two subradials and partly under the lower angle of the right posterior radial. The second anal is larger than the first, hexagonal, and rests upon one of the subradials, and extends above the top of the left posterior radial. The third anal is hexagonal, about as large as the first, on which it rests, and it extends nearly half its length above the top of the posterior radial on the right. The fourth and fifth anals are smaller, the one resting on top of the second anal and the other on the third. Column unknown.

Geological position and locality: Top of the geodiferous shales of the Keokuk group, one mile below Keokuk, Iowa.

Nos. 181 and 213 of Mr. L. A. Cox's collection.

I take pleasure in dedicating this beautiful species to my worthy friend and co-laborer, Mr. Orestes St. John.

POTERIOCRINUS LATIDACTYLUS, Worthen.

Pl. XXVIII, Fig. 6.

Poteriocrinus latidactylus, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 8.

This interesting species is only represented by a single imperfect specimen, showing the posterior side of the body, and a part of three of the rays.

Body mamillæform, once and a half as wide as high to the top of the first radials, and composed of smooth, closely joined plates. Basals unknown. Subradials nearly as large as the radials, length and breadth about equal, four of them hexagonal counting three angles below, the left posterior one larger than those on the anterior side and heptagonal. Radials pentagonal, once and a half as wide as high, and truncated straight across their upper margins for the reception of the brachials. These are of the same form and a little larger than the radials, and support on their upper sloping sides the first divisions of the rays. The arms are composed of broad, short, quadrangular plates, resembling closely the arms of *Woodocrinus* and *Bursacrinus*. In two of the rays which are partly preserved in the specimen before me, a second bifurcation takes place on the fourth plate above the brachials, beyond which the arm structure is unknown. The first arm-plates in the two posterior rays are about twice as long as the succeeding ones.

Three anal plates are visible; the first one is larger than the others, and rests between the upper angles of the two posterior subradials. The second rests on top of the left posterior subradial, and the third, which is smaller than either of the others, rests upon the first, and above this the lower margins of two or more succeeding plates can be seen.

Column stout, covering the entire width of the base, and composed at first of nearly equal joints that decrease in diameter below, and pass into a series of alternately thick and thinner joints as the distance from the base increases.

Position and locality: Upper part of the Keokuk limestone, Hamilton, Illinois.

No. 401 of Mr. L. A. Cox's collection.

POTERIOCRINUS PENICILLIFORMIS, Worthen.

Pl. XXVIII, Fig. 9.

Poteriocrinus penicilliformis, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 8.

Body small, forming below the summit of the radial plates a low cup, about twice as wide as high. Basals, and the lower angle of the subradials, concealed under the first columnar joints.

Subradials about as long as wide, except the one on the posterior side, which is a little longer than the others. Radials about twice as large as the basals, wider than long, and truncated squarely across their upper margins for the reception of the brachials. Brachials twice as long as wide, four of them pentagonal, constricted in the middle, and supporting two arms which continue simple to their extremities. The anterior ray has a long quadrangular brachial plate supporting a single arm, making nine arms altogether for this species.

Arms composed of rounded joints that are generally longer than wide, but slightly wedge-shaped, giving off strong pinnules from their longest sides.

Column slightly larger at its junction with the body than below, composed of alternately thicker and thinner joints.

First anal plate longer than wide, pentagonal, and rests partly between two of the subradials and under the right posterior radial. Above this a double series of small anal plates can be seen, the first of which rests on top of the left posterior subradial, and the second on the first anal.

This little crinoid is related to that described by Meek and Worthen in the second volume of the Geol. Survey of Illinois, p. 288, pl. 17, fig. 6, under the name of *Scaphiocrinus decadactylus*, but differs from it in the proportions of the body plates, and especially in its brachials and arm plates.

Position and locality: Upper part of the Keokuk limestone, Hamilton, Illinois.

No. 269 of Mr. L. A. Cox's collection.

POTERIOCRINUS TENTACULATUS, Worthen.

Pl. XXVIII, Fig. 11.

Poteriocrinus tentaculatus, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 10.

Body of medium size, depressed cup-shaped, more than twice as wide as high. Base depressed, basal plates small and concealed in the basal cavity. Subradials as long or longer than wide, three hexagonal and two on the anal side heptagonal.

Radials about twice as wide as long; heptagonal, and truncated squarely across their upper margins for the reception of the brachial series.

Brachials two, the first quadrangular, and the second pentangular, both as wide or a little wider than the radials; the second supporting on its upper angles the first divisions of the arms. The arms are composed of wide, short, quadrangular joints, and bifurcate the second time on the fourth and sixth plates above the brachials, beyond which they are all simple to their extremities, making four arms to each ray. Above the second bifurcation the plates of the arms gradually diminish in width, and become slightly wedge-formed, giving off strong pinnules from their longest sides.

Anal area proportionately large, with nine small anal plates visible. The first is pentagonal, and rests between two of the subradials and partly under one side of the right posterior radial. The two succeeding anals are larger, placed side by side, their lower margins resting, the left one on the truncated margin of one of the subradials, and the other between the upper angle of the first anal and the left margin of the first radial to the right. The next series of anals consists of three smaller plates placed side by side, and these are succeeded by three more that are not fully exposed.

Column unknown.

Position and locality: Upper shales of the geode bed, one mile below Keokuk, Iowa.

No. 403 of Mr. L. A. Cox's collection.

POTERIOCRINUS OCCIDENTALIS, Worthen.

Pl. XXVII. Fig. 2.

Poteriocrinus occidentalis, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, page 10.

Body cup-shaped, about twice as wide as high. Base depressed, the basals small and hidden under the first columnar joints. Subradials hexagonal and heptagonal, the lower angle curving under to form a part of the basal concavity.

Radials pentangular, nearly twice as wide as long, with a gaping suture between them and the brachials.

Brachials on four of the rays pentangular, widest below, slightly constricted in the middle, and angular above, supporting on their sloping sides the first division of the rays. Another bifurcation takes place on the tenth plate above the brachials in these four rays, beyond which they are simple to their extremities. The anterior brachial is quadrangular, constricted above, and supports a single arm, making 17 arms altogether for this species.

The anal side of the specimen is distorted so that the number and form of the anal plates cannot be clearly determined; but three can be seen; the second one much larger than the others, and apparently arranged as usual in this genus.

Column moderately stout, round and composed at the summit of evenly-sized plates, that alternate with thinner ones below.

This species is nearly related to *Pot.* (*Scaph.*) *unicus*, of Hall, but differs essentially from that in the number and bifurcation of the arms.

Position and locality: Upper beds of the Keokuk limestone, Hamilton, Illinois.

No. 170 of Mr. L. A. Cox's collection.

POTERIOCRINUS ASPER, Worthen.

Pl. XXVII, Fig. 8.

Poteriocrinus asper, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 11.

Body of medium size, basin-shaped, base slightly depressed, the basal plates being concealed by the columnar joints. Subradials prominent, length and breadth about equal, the lower angles forming a part of the basal concavity, and the upper angles depressed to correspond with similar depressions in the lower margins of the radial plates.

Radials short, about as wide as long, pentagonal, depressed at their lower angles, with a gaping suture between them and the succeeding brachials.

Brachials two, the first quadrangular, the second sharply angular above, and but little narrower than the radial series. A slight angular prominence extends lengthwise across the brachial plates, and the same may be seen on the lower portion of the arms under a good glass.

Arms on the anterior ray, after the first division on the second brachial, divide again on the fourth and sixth plate, and both the outer divisions again on the eighth plate, while the inner one appears to be simple after the second division, thus giving six arms to this ray. The antero-lateral rays appear to divide once more, giving eight arms to those rays.

Arm pieces rounded, moderately wedge-shaped, and diminish rather rapidly in width toward their extremities. Delicate pinnules are given off from their longest sides. Anal plates and column unknown.

The depressions at the angles of the body plates, give a rugged appearance to the body of this species, and will serve to distinguish it from the other forms with which it is associated.

Position and locality: Upper part of the geodiferous shales of the Keokuk group, one mile below Keokuk.

No. 191, Mr. L. A. Cox's collection.

POTERIOCRINUS BRIÆRIUS, Worthen.

Pl. XXVII, Fig. 4.

Poteriocrinus briœrius, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 12.

Body of medium size, cup-shaped, base depressed; the basal plates small, not extending beyond the columnar facet. Subradials prominent in the center and depressed at the angles, three hexagonal and two on the posterior side rather larger than the others, and heptagonal.

Radials pentagonal, nearly twice as wide as long, depressed on their lower margins to correspond with the depressions in the subradial plates. They are constricted across the middle, and projecting on their upper margins, with a distinct suture between them and the brachial plates.

First brachial quadrangular, the second pentangular, sharply angular above, giving support on its upper sloping angles to the first division of the rays.

The arms on the three anterior rays, after their first division on the second radials, divide at least four times, and one of them, the left antero-lateral ray five times, the division in every case taking place on the outer branch, as in *Zeacrinus*, while the inner branches continue single to their extremities. The divisions generally occur on the sixth, eighth, twelfth or sixteenth plate, making ten arms to two of these rays, which is probably the normal number, and eleven to the other. On the posterior rays, these divisions take place on the fourth, sixth and eighth plates. This gives an arm formula of fifty arms, as the normal number for this species.

First anal plate hexagonal, about as large as the smallest subradials, second and third rather smaller than the first, and all arranged as usual in this genus. They are all depressed at the angles, though not quite so much as the other plates of the body. Column unknown.

Position and locality: Upper part of the geodiferous shales of the Keokuk group, one mile below Keokuk.

Nos. 100 and 185 of Mr. L. A. Cox's collection.

POTERIOCRINUS ASPERATUS, Worthen.

PL. XXVIII, Fig. 2.

Poteriocrinus asperatus, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 12.

Body depressed, forming a low saucer-like cup below the summit of the radial plates. Base depressed, and basal plates concealed by the upper columnar joints. Subradials small, their lower angles concealed in the basal concavity.

Radials about twice as wide as long, pentagonal, without any well defined suture between them and the first brachial plates.

Brachials two, about the same size as the radials, the first quadrangular, and the second pentangular, giving support above to the first divisions of the rays.

Arms composed of rounded, nearly quadrangular joints, and after the first division on the second brachial they divide twice more in the posterior rays, first on the seventh, and each division again on the tenth plate, making eight arms to each of these rays. The other rays are partially embedded in the matrix, minute projections are visible with a good glass on the outer side of the arm plates, that give a roughened aspect to the whole specimen, and has suggested the specific name, and will also serve to distinguish it from nearly related species.

Anal plates so closely anchylosed that their forms cannot be clearly determined, but the first one rests between two of the subradials, and is succeeded by a double series of smaller plates that apparently go to form the base of the ventral tube. Traces of coarse striæ, or rows of granules, extending across the brachial plates, as well as the radials, can be seen with a good glass.

Column round, composed of rather even joints, with numerous delicate cirrhi attached to it at short intervals.

Position and locality: Upper part of the geodiferous shales of the Keokuk group; one mile below Keokuk.

No. 234 of Mr. L. A. Cox's collection.

POTERIOCRINUS ARACHNÆFORMIS, Worthen.

Pl. XXVIII. Fig. 12.

Poteriocrinus arachnæformis, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 13.

Body small, obconical, length and breadth about equal, gradually swelling from the base to the summit of the radial series. Basals projecting more than half their length beyond the column, and forming by themselves a low, pentagonal cup. Subradials comparatively large, three hexagonal, and two heptagonal. Radials smaller than the subradials, the articulating scar semi-circular, and occupying only about half the width of the plate, with a projecting rim around its outer margin.

Only one anal plate is preserved in the specimen under description, which is about half as large as the largest of the subradials between which it rests, and it extends up to the summit of the right posterior radial. The left posterior subradial is truncated at the summit for the support of the second anal, which is not preserved.

Only one of the rays is partially preserved. In this there are five brachials, the last one of which is an axillary plate, and supports the first divisions of the ray, one of which divides again on the third plate, beyond which the arms are not preserved. The arms are composed of long, slender, rounded joints, generally twice as long as wide.

Column unknown.

Position and locality: Keokuk limestone, Warsaw, Ill.

No. 2,464, Illinois State collection.

POTERIOCRINUS NAUVOOENSIS, Worthen.

Pl. XXVIII. Fig. 10.

Poteriocrinus Nauvooensis, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 13.

Body small, cup-shaped; the plates being displaced somewhat by crushing, prevents a complete diagnosis.

Basals small, and hidden by the first columnar joints. Subradials as high or higher than wide, and sharply angular above. Radials pentagonal, wider than long. First brachial quadrangular, second brachial pentagonal, and both as wide or a little wider than the radials below.

The arms of only one of the rays, the left antero-lateral, is preserved so that its structure can be made out. This ray divides on the second brachial, and the left branch twice more on the sixth and eighth plate above, while the right branch divides at least four times on the sixth and eighth plates, making at least eight arms to this ray. Anal series cannot be seen clearly enough to be fully determined; they are apparently arranged as usual in this genus.

Column round, and composed of thin, unequal joints.

This species is evidently nearly related to Hall's *Pot.* (*Scaph*) *æqualis*, but differs from that in the relative size of its subradial plates, and in the number and mode of bifurcation of the arms.

Position and locality: Keokuk limestone, Nauvoo, Ill.

No. 2,465, Illinois State collection.

Poteriocrinus Otterensis, Worthen.

Pl. XXVIII, Fig. 4.

Poteriocrinus Otterensis, Worthen, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 14.

Body above the medium size, basin-shaped, about once and a half as wide as high, base depressed and the basal plates hidden by the column, which is quite stout and pentalobate where it joins the body.

Subradials about one-fourth wider than long, the lower angle curving inward to form a part of the basal concavity. The center of these plates is smooth and a little protuberant, with four deep indentations on their borders, two of which are lateral, to meet those of the adjacent subradials, and two directed obliquely upward to meet similar depressions in the radial plates.

Radials wider than long, constricted across the middle, and projecting on their upper margins, with two slightly oblique depressions below, that meet two of those in the subradial plates. They are pentagonal in form and support on their upper truncated margins the brachial series.

Brachials one to each of the postero-lateral rays, smaller than the radials, slightly constricted, and sharply angular above, giving support to the first divisions of the rays. Arm structure unknown.

Three anal plates are visible, the first nearly as large as the subradials, the others a little smaller, and all having from four to six depressions around their borders that correspond to similar depressions on adjacent plates. The anal plates have been shoved out of their true position by the crushing of the specimen, so that their relation to the adjacent plates cannot be clearly determined.

Position and locality: This unique form was obtained from the Keokuk limestone, on Otter Creek, Jersey county, Ill.

No. 2,466, Illinois State collection.

POTERIOCRINUS SUBRAMULOSUS, Worthen.

Pl. XXVII, Fig. 6.

Poteriocrinus subramulosus, WORTHEN, Feb. 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 14.

Body turbinate or obconical, higher than wide to the top of the radial series, and composed of very thin, smooth plates. Basals truncate below, about as high as wide, and forming by themselves a small patagonal cup a little more than half as high as wide.

Subradials about twice as large as the basals, four of them hexagonal, and two on the posterior side larger than the others and heptagonal. Only two of the rays are preserved in the specimen before me, and in one of these, the right posterior one, the radial plate appears to be quadrangular, and rests directly upon the upper margin of the large posterior subradial below. In the left antero-lateral ray the radial is pentangular, its lower angle fitting in between two of the subradials, as is usually the case in this genus.

Brachials two, the first quadrangular, and the second pentangular, both wider than long, and the last supporting on its sloping sides the first divisions of the rays. The arms in the right posterior ray divide again two or three times, first on the seventh plate, and the outer branch twice more on the eighth and twentieth plate, and the inner division at least once more about the twentieth plate, making as many as ten arms to this ray. The left antero-lateral ray, after its first division on the last brachial plate, gives off branches in each division on the eighth plate, the outer division dividing twice more on the eighth and twenty-second plate, and the inner division once more on the twenty-second plate, which is as far as the arms can be traced. There are at least ten arms each to these two rays, and possibly more. The anterior ray is but partially exposed, and seems to have an axillary plate about the twelfth series above the last brachial. The first anal plate is nearly as large as the smallest subradial, and rests between two of them, and a smaller second anal rests upon the first, above which a double series of small plates may be seen that probably form the base of a ventral tube. Column rather stout, the first plates covering the whole diameter of the truncated base.

This species is closely related to *Pot. concinnus*, of Meek and Worthen, Geol. Surv. of Ill., Vol. 5, page 490, pl. 14, fig. 3, but differs from that in its more elongate body, the very thin plates of which it is composed, as well as in the number and mode of bifurcation of the arms.

Position and locality: Keokuk limestone, Keokuk, Iowa.

Collection of the author.

POTERIOCRINUS RICHFIELDENSIS, Worthen.

Pl. XXX, Fig. 5.

Poteriocrinus Richfieldensis, WORTHEN, Feb., 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 15.

Body small, turbinate, length and breadth about equal. Basals moderately large in proportion to the entire body, projecting above the columnar facet so as to form a shallow pentagonal cup.

Subradials larger than the basals, the two on the posterior side the longest, and hexagonal.

Radials wider than long, pentagonal, with a well defined and rather gaping suture between them and the succeeding brachials. In the right posterior ray the brachial is twice as long as wide, pentagonal, supporting on its upper sloping sides the first divisions of the ray. In the left posterior ray the brachial is divided, making two brachials in this ray, the first quadrangular, and the second short and pentangular, but I am inclined to regard this as accidental, and to believe that one brachial to each ray is the normal number.

The first anal plate is a little longer than wide, hexagonal, and rests between the sloping sides of the two posterior subradials, and partly under the left side of the right posterior radial. The second anal is a little larger than the first, and rests on the upper margin of the left posterior subradial. The third annal is smaller than the others, and rests upon the first.

Arms composed of rounded joints, not wedge-shaped, and divide the second time on the eighth plate above the brachials, beyond which they are simple in the posterior rays, the only ones visible in our specimen.

Column round, composed of short joints, and rather thicker at the base of the calyx than below.

Position and locality: Shaly sandstones of the Kinderhook group, near Richfield, Ohio.

No. 2,474, Illinois State collection.

POTERIOCRINUS FOUNTAINENSIS, Worthen.

Pl. XXX. Fig. 11.

Poterierinus Fountainensis, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 17.

Body under medium size, rapidly spreading from the base to the top of the radial series, where it is about twice as wide as high. Basals small and concealed by the first columnar joints. Subradials hexagonal and heptagonal, length and breadth about equal. Radials once and a half as wide as long, pentagonal, with a well defined suture between them and the brachial plates. Brachials about twice as long as wide, pentagonal, and narrower in the middle than at the ends and supporting two arms on their upper sloping sides, the brachial on the anterior ray being longer and more constricted than the others. Arms apparently but two to the ray, and composed of long zigzag joints, constricted in the middle and giving off on alternate sides from their upper angles strong pinnules, that are about half as large in diameter as the arms.

The first anal plate is nearly quadrangular in form, and rests between two of the subradials and under the left side of the right posterior radial. The second and third are a little smaller than the first, and above these there is a double series of small plates that extend up to the base of the ventral tube.

This species is rather closely related to *Pot.* (*Scaph.*) *internodius*, of Hall, Iowa Report, part 2, but differs from that in the form and proportions of the plates of the body, and in the zigzag arrangement of the arms.

Position and locality: St. Louis limestone, Fountain creek, Monroe county, Illinois.

No. 2,455, Illinois State collection.

NOTE.—The *Scaphiocrinus decabrachiatus*, *S. internodius*, *S. scoparius* and *Zeacrinus intermedius*, described by Hall in the Iowa Report, part 2, were collected by the writer, and were all from the St. Louis limestone and not from the Chester group, a fact that it is necessary to bear in mind in the identification of these species with those from other localities.

POTERIOCRINUS TALBOTI, Worthen.

Pl. XXX, Fig. 7.

Poteriocrinus Talboti, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 17.

Body very short, basin-shaped, base depressed, and the basals hidden in the basal concavity.

Subradials short, curving inward below to form by their lower angles part of the basal depression.

Radials pantagonal, twice as wide as high, widest at their upper margins, and truncated squarely across for the reception of the brachial plates.

On the anterior ray, there are six or seven brachials, all becoming narrower upward so that the last is only about half as wide as the first. The last one is an axillary plate, and supports two arms that continue simple to their extremities. The other rays have but a single brachial, which is as large or larger than the radials on which they rest, pentagonal in form, and give support on their upper sloping sides to the first division of the rays. On the left antero-lateral ray the arms divide on the sixth plate, beyond which they appear to be simple, which would give four arms to this ray. If the posterior rays, which are concealed in the rock in our specimen, correspond with the antero-lateral ray, it would give eighteen arms to the entire animal. Anal area and column unknown.

I take pleasure in dedicating this species to my esteemed friend, Henry Talbot, Esq., of Waterloo, to whom I am indebted for many acts of personal kindness, and for some interesting fossils.

Position and locality: St. Louis limestone, Monroe county, Ill.

No. 2,470, Illinois State collection.

POTERIOCRINUS VALIDUS, Worthen.

Pl. XXVIII, Fig. 16.

Poteriocrinus validus, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 18.

Body more than twice as wide as high, forming a low, shallow cup. Basals small and concealed by the first columnar joints. Subradials hexagonal on the anterior side, strongly protuberant in the middle and depressed at the angles, giving a very rugged appearance to the outer surface of the body. Radials pentagonal, about twice as wide as long, depressed at their lower angles to correspond with the depressions of the subradial plates.

Brachials two, the first quadrangular, and the second pentangular, supporting on their upper sloping sides the first divisions of the rays. All the plates to the top of the second brachials possess the rugged character mentioned above. Anal series unknown. Arms not preserved on the anterior ray, but from the partial preservation of those on the posterior side there seems to be not more than two to each ray. Column round and rather delicate, composed, near the body, of joints of unequal size.

Geological position and locality: Warsaw beds of the St. Louis group, Warsaw, Ill.

No. 2,463, Illinois State collection.

POTERIOCRINUS CLAYTONENSIS, Worthen.

Pl. XXX, Fig. 6.

Poteriocrinus Claytonensis, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History. p. 18.

Body of medium size, basin-shaped, about once and a half as wide as high to the top of the radial series.

Basals small and entirely concealed in the basal concavity by the first columnar joints. Subradials nearly or quite as long as wide, their lower angles curving into the basal concavity.

Radials once and a half as wide as long, pentagonal, and truncated squarely across the upper margins for the reception of the brachial series.

Brachials on three of the rays about the same size and form as the radials, and give support on their upper sloping sides to the first divisions of the rays.

The arrangement and number of the arms cannot be determined from the specimen in hand, but in the right antero-lateral ray a bifurcation takes place on the sixth plate above the brachial, beyond which the divisions are unknown. The arms are composed of wide, short quadrangular plates, as in *Zeacrinus*, and would be closely joined when folded as in that genus. Three anal plates are preserved in the specimen under examination, the first one pentagonal, resting between two of the subradials, and partly under the sliping side of the right posterior radial, the second and third are smaller, one resting on the top of the left posterior subradial, and the other on the first anal.

Column rather stout, the upper joints filling nearly the whole concavity of the base, and composed of thick and thinner joints alternately arranged.

Position and locality: Warsaw beds of the St. Louis group, near Clayton, Adams county, Ill.

No. 2,460, Illinois State collection.

Poteriocrinus Illinoiensis, Worthen.

Pl. XXVIII, Fig. 17.

Poteriocrinus Illinoiensis, WORTHEN, Feb. 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 19.

Body of medium size, obconical, gradually tapering from the summit of the radials to the base.

Basal plates of moderate size, projecting more than half their length beyond the column, and forming by themselves a low, pentagonal cup.

Subradials as large or larger than the radials, two on the posterior side heptagonal, the others hexagonal.

Radials rather wider than long, pentagonal, and truncated squarely across their upper margins for the reception of the brachial series.

Brachials rather smaller than the radials, pentagonal, a little constricted above, the upper angle obtuse, and giving support to the first divisions of the rays. The arms are not preserved, in the only specimen yet found of this species, but from the very narrow plates that are to be seen in one of the rays, they probably continue simple above the first division on the brachial series.

First anal plate longer than wide, pentagonal, and resting between two of the subradials, and partly under the right posterior radial. Second anal larger than the first, hexagonal, and resting on the summit of the left posterior subradial. Third anal smaller than the first, on which it rests, and above this a double series of small plates are partly visible, that probably formed the base of the ventral tube.

Column round, and near the base composed of joints nearly equal in thickness.

Geological position and locality: Warsaw beds of the St. Louis group, Warsaw, Illinois.

No. 2,457, Illinois State collection.

Poteriocrinus Varsoviensis, Worthen.

Pl. XXVIII, Fig. 15.

Poteriocrinus Varsoviensis, WORTHEN, Feb. 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 19.

Body below the medium size, basin-shaped, a little more than twice as wide as high to the top of the radial series.

Base depressed, the basal plates and the lower angles of the subradials forming the basal depression.

Subradials on the anterior side hexagonal, sharply angular above and extending up about half the length of the radial plates.

Radials pentagonal, wider than high, the articulating scar occupying the entire width of the plate, with a well-defined suture between the radial and brachial series.

Brachials, two to the ray on the anterior side, the first quadrangular and the second pentagonal, sharply angular above, and supporting on their sloping sides the first divisions of the rays. On two of the rays the arms bifurcate again on the sixth plate above the brachial series, beyond which they are unknown. All the plates of the body are finely rugose. Anal series unknown.

Column slightly pentagonal where it joins the body, and composed of alternate thin and thicker joints, but below more massive joints are intercalated at short intervals.

Geological position and locality: Warsaw beds of the St. Louis group, Warsaw, Illinois.

No. 2,458, Illinois State collection.

Poteriocrinus spinobrachiatus, Worthen.

Pl. XXIX, Fig. 1.

Poteriocrinus spinobrachiatus, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 20.

Body of medium size, basin-shaped, about twice as wide as high to the top of the radial series. Base slightly depressed, the under basals small and concealed by the first columnar joints.

Subradials about as wide as high, the lower angles curved inward, forming a part of the basal concavity.

Radials about one-fourth wider than long, pentagonal, the upper margins concave, leaving a gaping suture between them and the brachial plates.

Brachials pentagonal, about as long as the radials, compressed laterally, so as to form a rather prominent ridge across the middle of the plate, ending at the upper angle in a rather obtuse point. All the body plates, including the second radials, are marked with rugose striations directed from above downward to the base, giving a rugose appearance to the surface of the body. The brachials are sharply angular above, and support the first arm plates, which are triangular, and one on each brachial is produced in front into a little node that covers the projection at the summit of the brachial plates. The succeeding arm plates are short, wedge-shaped, except the axillary plates, which are longer than wide, and produced outwardly into an obtuse point. All the other plates of the arms, where well preserved, show short spiniferous nodes on their outer margins.

The arms, after their first division on the brachials, divide again on the eighth or tenth plate, and the outer division once or twice more on the sixteenth to the twentieth plate, while the inner branches continue single to their extremities.

Column round, and near the top composed of short plates, the alternate ones projecting beyond the others.

Anal plates unknown.

This species is evidently related to the crinoid figured by Yandell and Shumard in their "Contributions to the Geology of Kentucky," without a description, but if their figure is correct, our speecis differs from their "*Cyathocrinus florealis*," in the form and relative proportion of the body plates, as well as in the bifurcations of the arms.

Position and locality: Chester limestone; Monroe county, Ill.

No. 2,436, Illinois State collection.

POTERIOCRINUS SALTERI, Worthen.

Pl. XXIX. Fig. 18.

Poteriocrinus Salteri, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 21.

Body small, basin-shaped, rather more than twice as wide as high. Base depressed, and basal plates concealed in its concavity.

Subradials about as long as wide, those on the anterior side hexagonal, the lower angles curving into the basal depression, protuberant and slightly depressed at their upper angles.

Radials pentangular, about once and a half as wide as long, slightly depressed at their sides and lower angles, and showing a distinct suture above, where they join the brachial plates.

Brachials two to the anterior ray, the first one of which is quadrangular, and wider than high. The second is pentagonal, longer than wide, its upper angle produced into an obtuse node, and supporting on its upper sloping sides the first divisions of the arms. The two antero-lateral rays have a single brachial, about the same size and form of the second brachial on the anterior ray, and support on their upper sides the first divisions of the rays.

The arms are composed of rounded, quadrangular joints, and all divide again on the sixth plate above the brachials, which is nodose like the brachials, and beyond this they appear to be single to their extremities, giving four arms to each ray. Pinnules rather strong, and are given off on alternate sides from the upper margins of the arm plates. Anal plates unknown.

Column round, composed near the body of thick and thinner joints alternately arranged.

Position and locality: Chester limestone, Chester, Ill.

No. 2,419, Illinois State collection.

I take pleasure in dedicating this pretty species to Mrs. J. C. Salter, of Chester, in recognition of her enthusiastic labors in collecting the fossils of that very interesting locality.

POTERIOCRINUS SCULPTUS, Worthen.

Pl. XXIX, Fig. 8.

Poteriocrinus sculptus, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 21.

Body of medium size, basin-shaped, about twice as wide as high to the top of the radial series.

Base depressed, and the basals nearly concealed by the upper joints of a large pentalobate column, composed of thin plates with crenulated margins. The outer angles of the basals are barely visible in the pentalobate depressions of the column. The column decreases rather rapidly in size below its junction with the body.

Subradials a little wider than high, the two posterior plates a little larger than the others, and all crossed by two or three rounded ridges that culminate in the center of the plate in a sharp node.

Radials pentagonal, nearly twice as wide as high, with a sharp node in the center corresponding with those on the subradials, with distinct ridges extending obliquely from the nodes to meet those on the subradial plates.

Brachials two, the first quadrangular, half as long as wide, the second pentagonal, about as long as wide, and sharply angular above, supporting on its upper sloping sides the first arm plates, which are only preserved to the seventh plate above the last brachial in our specimen. The brachials and the arm plates as far as they are preserved are spine-bearing.

Two anals are preserved, the first is about half as large as the large subradials between which it rests, the second is smaller and rests on the truncated upper margin of the left posterior subradial, and both ornamented like the subradials.

This species is apparently related to *Z. Stimpsoni* of S. S. Lyon, but differs conspicuously from that, in the number of its brachials, as well as in minor details.

Position and locality: Chester limestone, Monroe county, Ill.

No. 2,445, Illinois State collection.

POTERIOCRINUS COLUMBIENSIS, Worthen.

Pl. XXIX, Fig. 6.

Poteriocrinus Columbiensis, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 22.

Body small, turbinate, rapidly spreading from the base to the summit of the radial plates.

Basal plates small, projecting about half their length beyond the column. Subradials about as high as wide, three hexagonal, and two on the posterior side a little larger and heptagonal.

Radials pentagonal, a little wider than long, except the one on the right posterior ray, which is narrower and nearly quadrangular. Brachials about twice as wide as long, rounded and constricted in the middle, pentagonal, supporting on their upper sloping sides two arms that continue single to their extremities.

Arms composed at their base of long, rounded joints, twice as long as wide, but decreasing in length above, the joints projecting laterally for the support of strong pinnules which are given off from each plate on alternate sides. Arm plates slightly cuneate in form, and the lateral projections give a zigzag appearance to the arms. Pinnules composed of round joints that are twice as long as wide where they join the arms.

The first anal is rather smaller than the second, and rests between two of the subradials and against the right posterior radial, and extends to the summit of that plate. The second radial rests on the upper margin of the left posterior subradial, and the third, which is smaller than the first, rests upon it, and extends up to the middle of the brachial on the right.

Column round, but only a few joints are attached to the specimen.

This species is closely allied to *Pot. (Scaph.) intermedius* of Hall, but differs from that in the form of its radials, but more especially in its long zigzag arms.

Position and locality: Chester limestone, near Columbia, Monroe county, Ill.

No. 2,138, Illinois State collection.

POTERIOCRINUS CLYTIS, Worthen.

Pl. XXX, Fig. 10.

Poteriocrinus clytis, WORTHEN, February, 1882.

Bulletin No. 1, of the Illinois State Museum of Natural History, p. 16.

Body small, obconical, length and breadth at the top of the radial plates about equal. Base truncated, the basal plates forming by themselves a low pentagonal cup. Subradials about as wide as high. Radials pentagonal, length and width apparently about equal, and support on their upper margins a single series of long slender arm plates, making but five arms to the entire animal.

The first arm plates on the two rays that are shown in the specimen before me, are three or four times as long as wide, and above these a series of ten or twelve shorter plates are preserved, all rounded externally and generally longer than wide. The anal plates are only partially preserved, but the form of the first can be clearly seen. It is pentangular, and rests between two subradials, and under the right posterior radial. Above this, part of a short cylindrical ventral tube is preserved. Remains of short delicate pinnules can be seen, attached to the inner borders of some of the arm plates.

Column rather stout, thicker at its junction with the body than below, and composed of short even joints that alternate with thicker ones below.

This species differs in its arm formula from all other *Poteriocrinidæ* known at this time, and its departure from the normal structure may prove of generic importance.

Position and locality: St. Louis limestone, Monroe county, Ill.

No. 2,456, Illinois State collection.

POTERIOCRINUS SIMILIS, Worthen.

Pl. XXX, Fig. 12.

Poteriocrinus similis, **WORTHEN, February, 1882.**

Bulletin No. 1, of the Illinois State Museum of Natural History, p. 23.

Body small, basin-shaped, twice as wide as high to the top of the radial series. The plates of the body are all slightly protuberant in the center, and depressed at the angles.

Base slightly depressed and basals concealed by the first columnar joints.

Subradials about as wide as high, hexagonal and heptagonal.

Radials wider than high, with a well-defined suture between them and the brachials. Brachials on the two posterior rays nearly three times as long as wide, constricted in the middle and angular above, supporting on their sloping sides the two divisions of the rays. In the right antero-lateral ray the brachial is only about twice as wide as high, its upper angle projecting so as to form a short node.

Arms two to each ray on the three rays visible, composed of rounded joints that, at first, are nearly twice as long as wide, but they gradually become shorter above. They all project laterally, and support strong pinnules, that are given off alternately from the longest side of the arm joints. The lateral projections of the joints give a zigzag arrangement to the arms.

Only one anal plate is visible in the specimen, and this is placed, as is usual in this genus, between two of the subradials, and under the left side of the right posterior radial.

Column round, and at its upper extremity composed of joints of nearly equal thickness.

This little crinoid is related to *Pot. Columbiensis*, from the same locality, but differs from that in its more depressed base, and in the slightly protuberant character of its body plates.

Position and locality: Chester limestone, Monroe county, Ill.

No. 2,446, Illinois State collection.

POTERIOCRINUS POPENSIS, Worthen.

Pl. XXIX. Fig. 12.

Poteriocrinus Popensis, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 23.

Boby small, obconic, gradually swelling from the base to the summit of the radial plates, where it is about once and a half as wide as long, composed of smooth, slightly protuberant plates. The basals project about one-half their length beyond the column, and form a low pentagonal cup.

Subradials on the anterior side hexagonal, about as wide as long. Radials pentagonal, once and a half as wide as long, and truncated squarely across their upper margins for the reception of the brachial plates.

Brachials pentagonal, length and breadth about equal, rounded externally, and sharply angular above, supporting on their sloping sides the first divisions of the rays. All the arms on the anterior side divide again on the seventh, eighth or ninth plate above the brachials, and one of them gives off a second branch on the eighth plate, while the others are not preserved beyond the second division above the brachials. The arms are composed of short wide plates, the two first above the brachials being about twice as long as the succeeding ones, and all a little wedge-shaped. The arms are only about half as wide above the second bifurcation as below. Anal plates unknown.

Column round, composed near the base of thick and thinner plates alternately arranged.

This species is related to *Pot.* (*Scaph.*) *Randolphensis*, Geol. Surv. of Ill., Vol. 5, page 551, but differs in its wider and more nearly parallel arm plates, as well as in the bifurcation of the arms.

Position and locality: Chester limestone, Pope county, Ill.

No. 2,351, Illinois State collection.

POTERIOCRINUS OKAWENSIS, Worthen.

Pl. XXIX. Fig. 2.

Poteriocrinus Okawensis, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 24.

Body of medium size, wider than high to the top of the radial series, composed of smooth, slightly convex plates.

Base truncated, the basal plates extending above and beyond the columnar facet, so as to form a low pentagonal cup. Subradials about as long as wide, three of them hexagonal, and two on the posterior side larger than the others and heptagonal.

Radials nearly or quite twice as wide as long, pentagonal, and truncated squarely across the entire length of their upper margins for the reception of the brachial plates.

Brachials one to the ray on the two rays visible, about the same size as the radials, supporting on their upper sloping sides the first divisions of the rays.

The arms are composed throughout of short, wide, quadrangular plates, and after the first division on the radials, divide again in the left posterior ray on the ninth or tenth plates and on the right antero-lateral, on the seventh and eleventh plate, beyond which they are simple as far as can be seen, making four arms to each of these rays.

The anal side of the specimen is distorted, but six small anal plates are partially exposed, arranged in two rows.

This species is related to *Pot.* (*Scaph.*) *Randolphensis* from the same horizon, but differs essentially from that, in the mode of bifurcation, and the wide, short plates of the arms.

Position and locality: Chester limestone, bluffs of the Okaw river above Chester, Randolph county, Ill.

No. 2,441, Illinois State collection.

POTERIOCRINUS VENUSTUS, Worthen.

Pl. XXIX, Fig. 13.

Poteriocrinus venustus, WORTHEN. February, 1882.

Bulletin No. 1, of the Illinois State Museum of Natural History, p. 24.

Body small, obconical, gradually swelling from the base to the top of the radial plates, where it is about once and a half as wide as long.

Basals extending about half their length above the first columnar joints, forming a low pentagonal cup.

Subradials nearly equal in size, three hexagonal, and two on the posterior side heptagonal.

Radials four, a little wider than long, the right posterior one rather narrower than the others, and all pentagonal.

Brachials one to each ray, nearly as wide below as the radials, constricted above, about once and a half as long as their greatest width, sharply angular above, and supporting on their sloping sides the first divisions of the arms.

Arms composed of rounded joints, the first nearly twice as long as wide, scarcely wedge-shaped below the second bifurcation, and dividing the second time on the ninth plate above the brachials, beyond which they continue simple, making four arms to the ray. Rather stout pinnules are given off from the longest side of the arm joints on alternate sides.

The first anal plate is rather more than half the size of the subradials, pentagonal, and rests between two of the posterior subradials, and under the lower side of the right posterior radial plate. The second and third are smaller than the first, the second resting partly on the summit of the left subradial, and the third on the summit of the first anal. Column unknown.

Position and locality: Chester limestone, Monroe county, Illinois.

No. 2450, Illinois State collection.

POTERIOCRINUS PECULIARIS, Worthen.

Pl. XXIX, Fig. 10.

Poteriocrinus peculiaris, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 25.

Body below the medium size, obconic; the basals being broken away from the specimen, its relative proportions cannot be exactly determined. Fragments of two of the basals that still remain attached show that they extended above and beyond the columnar facet.

Subradials about as high as wide, three of them hexagonal, and two heptagonal.

Radials pentagonal, somewhat irregular in size, the left posterior and the left antero-lateral ones being a little larger than the others, and all about once and a half as wide as long.

Brachials one to the ray, that on the anterior ray rather the longest, the others about as long as wide, constricted in the middle, and sharply angular above, supporting on their sloping upper sides the first arm plates.

The arms, after their first division on the brachials, divide again at unequal distances from the sixth to the tenth plate above the brachials on four of the rays visible in the specimen under examination, beyond which they continue simple to their extremities, making four arms to each ray. The arm joints are all slightly wedge-formed, and quite short above the second division, and support strong pinnules, which are given off from the longest sides of the joints.

The anal side presents an anomalous feature that I have not observed in any other species of *Poteriocrinus*. In addition to the ordinary anals placed as is usual in this genus, there is a pentagonal plate about as long as the radials, intercalated between the right posterior radial and the subradial below, elevating the lower angle of this radial to a level with the summit of the other radial plates. This may be only an abnormal development, and I was at first inclined to regard this as only a variety of *P. venustus*, but its shorter brachials and arm-plates, and different mode of bifurcation of the arms, seems to afford good grounds for considering it as a distinct species.

Position and locality: Chester limestone, Monroe county, Ill.

No. 2,448, Illinois State collection.

POTERIOCRINUS PROPINQUUS, Worthen.

Pl. XXIX, Fig. 9.

Poteriocrinus propinquus, WORTHEN, Feb., 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p 26.

Body below medium size, obconic or bell-shaped, spreading rather rapidly from its truncated base to the summit of the radial plates, where it is nearly twice as wide as high.

Basals about half as long as wide above their junction with the column, forming a shallow, pentagonal cup.

Subradials on the anterior side hexagonal, length and breadth about equal, their upper angles extending up about half the length of the radial plates. Radials one-fourth to one-third wider than high, pentagonal, with their upper margins squarely truncated for the reception of the brachial plates.

Brachials widest at their lower margins, not quite as long as wide, constricted in the middle, and sharply angular above, where they support the first divisions of the rays. Arms four to eight to the ray, so far as can be seen from the specimen under examination. The left posterior ray divides the second time on the eighth or ninth plate above the brachial, beyond which the arms appear to be simple to their extremities. The right antero-lateral arm bifurcates the second time on the eight or ninth plate, the right branch sending off two additional arms on the seventh, and again on the fourteenth plate, while the left branch gives off another arm on the eighth or ninth plate, beyond which it is not preserved. There are probably eight arms to this ray. The other rays are not preserved beyond the second bifurcation. The arms are composed of rather short, wedge-formed joints, that give off strong pinnules from their longest sides.

Anal area unknown. Column round, composed at first of rather even joints, with a thicker one intercalated at short intervals below. The calyx of this species could not be readily distinguished from several others that are found in the Chester limestone, but its long, slender arms, and their mode of bifurcation, are its distinctive characters.

Position and locality: Chester limestone, Monroe county, Ill.

No. 2,437, Illinois State collection.

POTERIOCRINUS KASKASKIENSIS, Worthen.

Pl. XXIX. Fig. 15

Poteriocrinus Kaskaskiensis, WORTHEN, Feb., 1882.

Bulletin No. 1, of the Illinois State Museum of Natural History, p. 27.

Body small, bell-shaped, nearly twice as wide as long to the summit of the radials, composed of rather thin, smooth plates, so closely anchylosed together that their relative size and form cannot be determined. The radials are nearly as long as wide, pentagonal, thickened on their upper margins with a lip-like suture between them and the first brachial plates.

Brachials two, the first quadrangular, the second pentagonal; length and breadth about equal, both rounded externally, and constricted, the second sharply angular above, and supporting on its sloping sides the first divisions of the rays.

Arms composed of rather long, wedge-shaped joints, that project slightly on their outer margins, giving them a somewhat zigzag appearance, and after their first division on the second brachials they all divide again on the eighth to the tenth plate above the brachials, giving four arms to each ray as the normal number. In one of our specimens, however, one arm gives off a branch near its extremity, making five arms to that ray.

Pinnules rather strong and attached to the longest side of the arm plates. Anal plates unknown. Ventral tube cylindrical, and about twice the diameter of the adjacent arms.

Column round, composed of short, even joints, with numerous cirrhi attached at short intervals on opposite sides, which are composed of rounded joints about half the diameter of those composing the column.

This species may be readily distinguished from *P. venustus* and *P. clytis*, by the bell-shaped form of its body and zigzag arrangement of the arms.

Position and locality: Chester limestone, bluffs of the Kaskaskia river, four miles above Chester, Ill.

No. 2,452, Illinois State collection.

POTERIOCRINUS CULTIDACTYLUS, Hall.

Pl. XXX, Fig. 1.

Poteriocrinus cultidactylus. HALL, 1859.

Supplementary report on the Palæontology of Iowa, p. 62.

"Body elongato-turbinate and slightly expanding at the base of the arms, which are regularly bifurcating and but slightly spreading. Basal and subradial plates unknown. Radial series consisting of three plates in each ray, the upper one of which is a bifurcating plate. First radial plates pentagonal, besides the truncated angles. Second radials about as long as wide, quadrangular with truncated angles. Third radials pentagonal, obtusely wedge-formed above, and supporting on each side a series of eight arm-plates, the upper one of which is a bifurcating plate; above this, on the outer side, there is a bifurcation on the twelfth to the sixteenth plate, while the division on the other side remains simple so far as can be traced in the specimen. This character applies to all except the anterior ray, where the bifurcation takes place on the twentieth plate above the first division.

The anal series consists of a number of small usually hexagonal plates.

The plates of the arms are round upon the exterior face, a little wider on one side than the other in alternating order. The surface is finely granulose, without peculiar markings."

The above description was not drawn from the specimen figured, but from one found many years ago, and now in the writer's collection, but was not accessible when the figures for this volume were drawn.

Position and locality: The specimen originally described was obtained from the Burlington limestone, near Hamburg, in Calhoun county, and the one figured from the same horizon at Montezuma, in Pike county, Illinois.

The latter is number 2,471 of the Illinois State collection.

GENUS ZEACRINUS, Troost.

ZEACRINUS COXANUS, Worthen.

Pl. XXVIII. Fig 1.

Zeacrinus Coxanus, WORTHEN, February, 1882.

Bulletin No. 1, of the Illinois State Museum of Natural History, p. 27.

Body of medium size, basin-shaped, more than twice as wide as high to the top of the radial series. Base depressed, and the basals, which are small, are concealed by the first columnar joints. Subradials hexagonal, once and a half as wide as their height above the basal concavity, which is in part formed by the upward curvature of their lower angles, their upper angles extending up nearly one-half the length of the radial series.

Radials nearly twice as wide as long, pentagonal, and truncated squarely across their upper margins for the support of the brachial series. The anterior ray has two brachials, the first one quadrangular, once and a half as wide as long, and the second short, pentangular, and supporting the first divisions of the ray. Each division of this ray bifurcates again on fourteenth or sixteenth plate, the outer division dividing again about the same distance above, making six arms to this ray.

The other rays, so far as can be seen from the only specimen we have seen, have only a single brachial plate, which is a little longer than the radial below, pentagonal, and supports on its upper angles two stout arms, which divide first on the sixth or seventh plate, the inner division continuing simple to its extremity, while the outer one divides twice more on the tenth to the twelfth plate, making eight arms to each of these rays, or thirty-eight to the entire individual.

Arms composed of short quadrangular joints, rounded exteriorly, giving off rather delicate pinnules from their inner margins. Anal series unknown. Column rather slender, composed of round plates, arranged in alternate series of thick and thinner joints. This beautiful species, the first discovered in the Keokuk limestone in Illinois, I take pleasure in dedicating to its discoverer, Mr. L. A. Cox, of Keokuk, to whom I am indebted for the use of the typical specimen.

Position and locality: Upper beds of the Keokuk limestone, Hamilton, Illinois.

No. 400 of Mr. Cox's collection.

ZEACRINUS KEOKUK, Worthen.

Pl. XXVIII. Fig. 3.

Zeacrinus Keokuk, WORTHEN, February, 1882.

Bulletin No. 1, of the Illinois State Museum of Natural History, p. 28.

Body of medium size, shallow, basin-shaped, about twice as wide as high. Base depressed and basal plates concealed by the first columnar joints.

Subradials on the anterior side hexagonal, curving below into the basal concavity, their upper angles extending up about half the length of the radial plates.

Radials pentagonal, nearly once and a half as wide as long. Brachials single on four of the rays, pentagonal, a little larger than the radial below, and supporting the first divisions of the rays. The anterior ray has four brachials, the first as long as both the succeeding ones, quadrangular and as wide below as the radial on which it rests. The two succeeding brachial plates are short and quadrangular, a little narrower than the first. The fourth is also short, subtriangular, and supports the first divisions of this ray. Both branches of the anterior ray divide again on the tenth plate, and the outer division the second time on the tenth plate above, making six arms to this ray. One of the antero-lateral rays, after its first division on the brachial plate, sends off an arm from each division on the sixth plate, the outer branches dividing again on the eighth to the tenth plate, making eight arms to this ray. The arm plates are but slightly rounded exteriorly, and nearly quadrangular in form. Anal plates unknown.

Column round, and composed near the body of rather thick, alternating with very thin plates.

Position and locality: Upper part of the geodiferous shales of the Keokuk group, one mile below Keokuk.

No. 217 of Mr. L. A. Cox's collection.

Zeacrinus Pikensis, Worthen.

Pl. XXX. Fig. 3.

Zeacrinus Pikensis, Worthen, Feb. 1882.
Bulletin of the Illinois State Museum of Natural History, p. 29.

Body of medium size, short, forming below the summit of the radial series a shallow cup about three times as wide as high. Basals small and entirely concealed in the basal concavity. Subradials rather longer than wide, and curving below so as to form a part of the concavity of the base.

Radials pentagonal once and a half, and the anterior one probably twice as wide as long, and truncated squarely across their upper margins for the reception of the brachial series.

The anterior ray has three brachials, the first one of which is as large as the radial below, the second one very short, and both quadrangular; the third is also short, but pentangular, supporting on its sloping sides the first divisions of the ray. One of these divisions bifurcates again on the eighth plate, and the other on the tenth, beyond which they appear to be simple to their extremities, making but four arms to this ray. The right antero-lateral ray and the left posterior ray have each a single brachial, which is nearly as long as wide, supporting on its sloping angles the first divisions of the rays. The two divisions of the right antero-lateral ray divide again on the sixth plate, and at least one of these divisions, and probably both the outer ones, divide again on the tenth plate, making six arms to this ray. If the other rays correspond with this, it would give twenty-eight arms as the full series for this species. Anal plates unknown. Column slender, and composed of round joints of unequal thickness.

Geological position and locality: Lower part of the Burlington limestone, Montezuma, Pike county, Illinois.

No. 2,462, Illinois State collection.

GENUS RHODOCRINUS, Miller.

RHODOCRINUS COXANUS, Worthen.

Pl. XXVIII, Fig. 7.

Rhodocrinus Coxanus, WORTHEN, Feb. 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 30.

Body of medium size, subglobose, base slightly depressed, the basal plates concealed by the first columnar joints. Subradials a little wider than long, their lower angles curved in to form a part of the basal concavity.

The first radials much larger than the succeeding ones, heptagonal in form; second radials nearly quadrangular, and the third hexagonal, supporting above the secondary radial plates, of which there is but one to each division of the ray.

Brachials, four to five, short, widening above, the upper one with a slightly-projecting angle in the middle, separating the first divisions of the arms. From two to five single, wedge-formed pieces succeed the brachials, above which the arms are composed of a double series of short, interlocking pieces, each one of which gives off a moderately-strong pinnule. In one of the specimens under examination the arms on the two rays visible continue single after the first bifurcation, making four arms to each ray; but in another specimen, apparently of the same species, a third branch is given off from the third plate above the first division, making six arms to these two rays.

From four to six inter-radials can be seen, the first of which is larger than the others, but owing to the crushed condition of the specimens, the exact form and number of these plates cannot be determined.

Column round, rather stout, and composed of alternately thin and thicker joints.

The specimen showing six arms to the ray also shows a marked prominence in the central portion of the body-plates, which is not seen in the other, and this we take as the type of *R. Coxanus*, and if these differences should be regarded as of specific importance, the name *R. polydactylus* might be used to designate the other variety.

Geological position and locality: Upper part of the geode bed, one mile below Keokuk.

Nos. 197 and 223 of Mr. L. A. Cox's collection.

GENUS PLATYCRINUS, Miller.

PLATYCRINUS MONROENSIS, Worthen.

Pl. XXX. Fig. 9.

Platycrinus Monroensis, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 30.

Body small, cup-shaped, about once and a half as wide as high. Basal plates extending about one-half their length beyond the first columnar joints, the lower margin projecting so as to form a narrow rim to the base. Radials wider than high, the articulating scar occupying only about one-third to one-half of their entire width.

Brachials single, narrow, subtriangular, sharply cuneate above, and supporting on their upper sides the first arm plates. On the two rays visible in the specimen under examination, the arms, after their first division on the brachials, divide again, both divisions once on the second plate above the brachials, and one of them the second time on the second arm plate above, giving five arms to each ray.

Arms composed at first of long, rounded joints, that are somewhat zigzag and projecting on their margins, where they give off strong pinnules, but towards their extremities they are composed of short, triangular pieces that also sustain pinnules on their longest margins. Pinnules quite stout, their diameter being about equal to one-third of the width of the plates to which they are attached.

Position and localities: St. Louis limestone, Monroe county Ill., and Blount county, Tenn.

No. 2,461, Illinois State collection.

GENUS ERETMOCRINUS, L. and C.

ERETMOCRINUS VARSOVIENSIS, Worthen.

Pl. XXVIII. Fig. 11.

Eretmocrinus Varsoviensis, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 30.

Body small and turbinate below the base of the arms. Basals short, slightly projecting on their lower margins, forming a well defined rim around the base.

Primary radials three, the first comparatively large, hexagonal or heptagonal, the succeeding ones small, one quadrangular and the other subtriangular, supporting on its upper angles the secondary radial series.

Secondary radials two, the first quadrangular and the second pentangular, supporting above the two divisions of the arms, giving four arms to each ray.

The two first arm plates are nearly quadrangular, and longer than those above. The third and fourth are nearly triangular, and are succeeded by a double series of slightly interlocking plates that spread out towards their extremities in the manner peculiar to this genus.

Interradials three, the first about twice as large as the succeeding ones. Anal series unknown.

Column at its junction with the body composed of thick, round joints that, a short distance below, are separated by thinner ones arranged alternately.

Surface of the body plates finely granulose, with a slightly elevated ridge crossing the plates, and extending to the top of the secondary series.

This species, minus the arms, closely resembles *Batocrinus caroli* (Hall's sp.) from the same beds, but differs in the number and structure of the arms, that having but sixteen while this has twenty.

Position and locality: Warsaw beds of the St. Louis group, Warsaw, Ill.

No. 2,459, Illinois State collection.

GENUS ONYCHOCRINUS, L. and C.

ONYCHOCRINUS DISTENSUS, Worthen.

Pl. XXIX. Fig. 5.

Onychocrinus distensus, WORTHEN, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 31.

Body of medium size, composed of smooth, massive plates. Basals concealed by the column.

Subradials on the anterior side sharply angular beyond the columnar facet, forming a low, pentagonal cup.

Radials five, the first pentagonal, about one-fourth wider than long; the second, third and fourth, quadrangular, and nearly as wide as the first, their width being equal to about once and a half their length. The fifth radial is pentagonal, and supports upon its upper sloping sides the divisions of the rays. The arms, beyond the first division, throw off armlets at intervals of five or six plates to their extremities on the only rays that are preserved in the specimens obtained.

None of the specimens show more than two or three inter-radial plates. The first of these is hexagonal, about as wide as long, and this was apparently succeeded by a series of three smaller plates that are but partially preserved. Anal plates unknown.

Column round, largest at its junction with the body, and composed of very thin, even joints.

Position and locality: Chester limestone, Monroe county, Ill.

No. 2,442, Illinois State collection.

GENUS TAXOCRINUS, Phillips.

TAXOCRINUS FLETCHERI, Worthen.

Pl. XXX, Fig. 2.

Taxocrinus Fletcheri, WORTHEN, February, 1882.

Bulletin of the Illinois State Museum of Natural History, p. 31.

Body, with arms complete, ovate in outline, lobate, composed of thick, massive plates. Basals small, and concealed by the column. Subradials extending nearly half their length beyond the columnar facet, forming by themselves a low, pentagonal cup. Primary radials three in each ray, gradually widening from the first to the third, which is an axillary plate, giving support to the first plates of the second series. Secondary radials three, more than half as wide as the first, the last one supporting the first plates in the Tertiary series. Above the secondary series some of the arms, if not all, divide again on the fifth plate, above which they become quite slender.

On the anal side of the specimen two series of plates are preserved. The first one is hexagonal in form, and rests between the upper angles of two of the subradials. In the next series there are three plates, each about half as large as the first, the middle one resting directly upon it, and the others resting between the upper angles of the first anals and the adjacent first radials. Above this second row of anal plates another series is only partly visible. Interradials, one or more to each space, but their form and number can not be clearly determined from the specimen in hand.

Column round, larger at its junction with the body than below, and composed at first of thin, even joints, but below thicker plates are intercalcated at irregular intervals.

Position and locality: Kinderhook group of the Lower Carboniferous series, Marshalltown, Iowa.

Dedicated to Mr. Thos. Fletcher, of Keokuk, Iowa, to whom I am indebted for this and other interesting fossils.

The author's collection.

GENUS CYATHOCRINUS, Miller.

CYATHOCRINUS PARVIBRACHIATUS, Hall.

Pt. XXVIII. Fig. 5.

Cyathocrinus parvibrachiatus, HALL, 1861. Desc. New Crinoidea.

Cyathocrinus Hamiltonensis, WORTHEN, February, 1882.

Bulletin No. 1, of the Illinois State Museum of Natural History, p. 32.

Body of medium size, basin-shaped, base deeply impressed, width of body about twice as great as the height to the top of the first radial series. Basals small and concealed in the basal concavity by the upper joints of the column.

Subradials hexagonal, counting three angles on the under side, and curve into the basal concavity; width and length nearly equal; slightly convex, the greatest convexity being a little below the center of the plate.

Radials about twice as wide as long, those on the anterior side pentagonal, the articulating facet for the reception of the brachials occupying about one-half the width of the plate. In the anterior ray the first bifurcation takes place on the fourth brachial, and in one of the antero-lateral rays on the third, and a second bifurcation on each division of this ray takes place on the third plate above the first. The arms diminish rapidly in size beyond the first bifurcation. Anal side unknown.

Column rather slender, and composed of short, round, even joints.

Position and locality: Upper beds of Keokuk limestone, Hamilton, Ill.

No. 174 of Mr. L. A. Cox's collection.

NOTE. After publishing a description of this form in 1882, I ascertained that the error in its diagnosis, as published in the Boston Journal of Natural History, was due to a typographical error, and therefore restore the name adopted by Hall in 1861.

CYATHOCRINUS MARSHALLENSIS, Worthen.

Pl. XXX. Fig. 4.

Cyathocrinus Marshallensis, WORTHEN, February, 1882.

Bulletin No. 1, of the Illinois State Museum of Natural History, p. 33.

Diagnosis: Body mamillate, length and breadth about equal, and truncated at the base where it joins the column. Basal plates small, longest on the anterior side, angular above, and forming by themselves a shallow pentagonal cup. Subradials about as high as wide, four of them of equal size and hexagonal, the fifth on the anterior side nearly twice as large as the others and heptagonal. The radials on four of the rays are about the same size as the smallest subradials, pentagonal in form, their lower angles fitting into depressions between the subradials, constricted from the lower lateral angles upward, so that the upper margins, which support the brachials, are only about half as wide as the greatest width below.

Brachials three on these four rays, narrower than the radials, two of them quadrangular, and the third angular above, supporting the first divisions of the arms. The lateral spaces between the brachials, and extending below to the middle of the radials, appears to have been filled by a calcareous integument, or with minute plates that are too small to present definite forms under an ordinary glass.

On the anterior side of the specimen, the large anterior subradial is succeeded by a quadrangular radial resting directly upon its truncated upper margin, and this is succeeded by two or more quadrangular brachials, beyond which its structure cannot be made out.

The arms after the first bifurcation on the third brachial, divide again on the sixth or seventh plate, and some of the branches once or twice more, higher up. They are composed of rather long, rounded quadrangular joints, decreasing gradually in size to their extremities. Anal plates unknown.

Column round, very strong at the base of the calyx, decreasing about one-half in diameter a half inch below, and composed of rather thin, even joints.

Position and locality: Kinderhook group, Marshalltown, Iowa.

The author's collection.

GENUS EUPACHYCRINUS, Meek and Worthen.

EUPACHYCRINUS ASPERATUS, Worthen.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Three anal plates are visible, the first is pentagonal, larger than both the others, nodose like the subradials between which it rests, while its upper angle extends a little above the radial on the right. The second anal rests upon the upper truncated margin of the left posterior subradial, and the third between the first and second anals.

Column round and rather small for the size of the body.

This species is related to Lyons' *E. quator-decimbrachialis*, but differs in its less massive form, and in the number of its arms.

Position and locality: Chester limestone, Monroe county, Ill.

No. 2,413, Illinois State collection.

Eupachycrinus Monroensis, Worthen.

Pl. XXIX, Fig. 16.

Eupachycrinus Monroensis, Worthen, February, 1882.

Bulletin No. 1, of the Illinois State Museum of Natural History, p. 34.

Body of medium size, low, basin-shaped, composed of massive plates.

Basals small, triangular above and below, the inner angles bent downward under the column, and the outer ones bent slightly upward between the subradials.

Subradials protuberant, sub-hemispheric externally, generally pentangular, the one on the anal side a little larger than the others, and truncated on its upper margin for the support of the anal plate.

Radials pentagonal, about twice as wide as long, and truncated entirely across their upper margins for the reception of the radial series.

Anals one, quadrangular, length and width about equal, extending above to a level with the summit of the adjacent radials, and resting below on the truncated upper margin of the right posterior subradial.

Arms and column unknown.

This species is related to *Eupach. formosus*, Geol. Surv. Ill., Vol. 5, page 549, but differs from that in the proportions of its radial plates and the subglobose character of its subradials.

Position and locality: Chester limestone, Monroe county, Ill.

No. 2,417, Illinois State collection.

GENUS DICHOCRINUS, Munster.

DICHOCRINUS HAMILTONENSIS, Worthen.

Pl. XXVII., Fig. 10.

Dichocrinus Hamiltonensis, WORTHEN, February, 1882.

Bulletin No. 1, of the Illinois State Museum of Natural History, p. 35.

Body small, length and breadth apparently about equal, though from the crushed condition of the body plates the exact proportions of the body can not be accurately determined. Basals about half as long as the radials, forming by themselves a low, shallow cup.

Radials quadrangular, nearly once and a half as long as wide, with a narrow, articulating scar at the summit for the reception of the brachial series.

Brachials three, the last one longer than those below, and supporting on its upper sloping sides the first arm plates.

Arms two to each ray, as far as can be seen in the specimen before me, composed of short, wedge-shaped pieces, rounded exteriorly, and giving off from their longest sides rather strong pinnules.

Column unknown.

This species is nearly related to *D. ficus*, of Lyon and Casseday, but differs from that in the shorter form of the body and in the number of its brachial pieces, which in their species is only two to each ray.

Position and locality: Upper part of the Keokuk limestone, Hamilton, Ill.

No. 267 of Mr. L. A Cox's collection.

DICHOCRINUS COXANUS, Worthen.

Pl. XXVII, Fig. 7.

Dichocrinus Coxanus, WORTHEN, February, 1882.

Bulletin No. 1 of the Illinois State Museum of Natural History, p. 35.

Body small, ovate in outline, pointed at the base and contracted at the summit of the radial series, so that its greatest diameter is near the base of the radial plates.

Basal plates nearly three-fourths as long as the radials, forming by themselves a rather deep cup.

Radials longer than wide, lateral borders nearly straight, slightly contracted at their summits, the articulating scar for the reception of the brachial series occupying about one third of the width of their upper margins.

Brachial plates small, apparently two in number, the second one being the longest, and supporting on its upper sloping sides the first arm plates.

Arms two to each ray, composed of short, rounded joints, which give off strong pinnules from their inner borders. Anal side and column unknown. The surfaces of the body plates are marked by obscure longitudinal ridges that will serve to distinguish the species from any other heretofore described from this horizon.

Position and locality: Upper part of the Keokuk limestone, Hamilton, Ill.

No. 11 of Mr. L. A. Cox's collection.

GENUS TALAROCRINUS, Wachs. & Spr.

TALAROCRINUS OVATUS, Worthen.

Pl. XXIX, Fig. 11.

Talarocrinus ovatus, WORTHEN, Feb., 1882.

Bulletin No. 1, of the Illinois State Museum of Natural History, p. 36.

Body above the medium size, ovate in general outline, lobate as viewed from above or below.

Basals about half as high as wide, impressed below, and pentagonal above, with a slight depression at their lateral borders.

First radials about one-third longer than wide, the anterior one pentangular, the others quadrangular, and all protuberant. The succeeding radials not visible.

The first anal is as large or a little larger than the first radials, heptagonal, having four distinct angles above and three below. It is succeeded by three small anals, the central one of which is pentagonal, and rests on the truncated summit of the first anal, while the other two, the form of which can not be clearly seen, rest upon its upper lateral angles. Above this there is one or two series of very small plates surrounding the anal opening.

The vault is composed of very small, smooth plates, except the central one, which is larger, and produced into a pointed spine. In one of our specimens there is a spine-bearing plate, between the arm openings and the central spine on two of the rays. Arm openings two to each ray. Arms and column unknown.

This species is related to *T. sexlobatus*, (Shumard's sp.) but differs from that in its more symmetrical form, its less protuberant radial and anal plates, and less nodose summit.

Position and locality: Chester, limestone, Monroe county, Illinois· No. 2,453, Illinois State collection.

GENUS AGASSIZOCRINUS. Troost.

AGASSIZOCRINUS PAPILLATUS, Worthen.

Pl. XXIX. Fig. 17.

Agassizocrinus papillatus, WORTHEN, Feb., 1882.

Bulletin No. 1. of the Illinois State Museum of Natural History. p. 36.

Body rather below the medium size, subovate, width at the summit of the radials a little more than the length, composed of massive, slightly rounded plates that are separated by well-defined and deep sutures.

Basals pentangular, about as wide as long, and rounded below, where their inner margins form the walls of a very small pentapetalous opening for the attachment of a very delicate round column, two or three joints of which remain attached to one of our specimens.

Subradials, three hexagonal, counting three angles below, and two on the posterior side heptagonal, length and breadth about equal.

Radials pentangular, nearly twice as wide as long, except the two posterior ones, which are rather narrower than the others.

Brachials about the same size and form as the radials, and support on their upper sloping sides the first arm plates. Arms two to each ray, composed of quadrangular joints that gradually diminish in width to their extremities.

Anals, three visible: the first is nearly as large as the radial plates, pentagonal and situated as in *Poteriocrinus*, between two of the subradials, and partly under the left side of the right posterior radial. The second is about half as large as the first, and rests on the upper truncated margin of the left posterior subradial. The third is very small, and rests upon the upper angle of the first anal.

Position and locality: Chester limestone, Monroe county, Illinois. No. 2,444, Illinois State collection.

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AGASSIZOCRINUS HEMISPHERICUS, Worthen.

Pl. XXIX, Fig. 7.

Agassizocrinus hemisphericus, WORTHEN, Feb. 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 37.

Body small, bowl-shaped, or hemispherical in outline, about once and a half as wide as high to the summit of the radial series, rounded at the base, and composed of massive, protuberant plates.

Basals small, projecting but slightly below the subradials, forming a little pentagonal star. No columnar facet is visible.

Subradials a little longer than wide, strongly protuberant, three of them pentagonal, and two on the posterior side hexagonal.

Radials pentagonal, three of them rather more than once and a half as wide as long, the two on the posterior side rather narrower than the others, and all truncated squarely across their summits for the reception of the brachials. Sutures between all the plates of the body distinct.

Brachials as wide below as the radials, but strongly constricted and sharply angular above, where they give support to the two divisions of the rays. The arm-plates attached are three in number, the first nearly twice as long as the succeeding ones, and all quadrangular in form.

Four anal plates are visible, the first is protuberant, pentangular, about half as large as the largest radials, and rests squarely upon the truncated upper margin of the right posterior subradial and under the left side of the right posterior radial. The second anal is about half as large as the first, longer than wide, and rests on the upper margin of the left subradial. The other anals are smaller; the third rests between the first and second, and the fourth on the summit of the second. Column unknown.

Geological position and locality: Chester limestone, Randolph county, Illinois.

No. 2,451, Illinois State collection.

MOLLUSCA.

BRACHIOPODA.

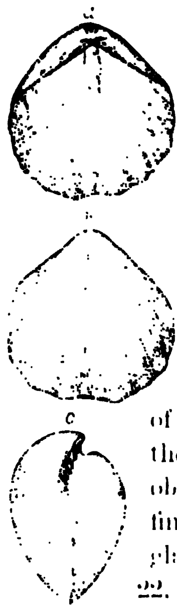
Genus CAMEROPHORIA, King.

Camerophoria Giffordi, Worthen.

a, View of dorsal valve; b, ventral valve; c, profile view.]

Camerophoria Giffordi, Worthen, February, 1882.

Bulletin No. 1, of the Illinois State Museum of Natural History, p. 39.



Shell above the medium size, broadly ovate or subcircular in general outline. Dorsal valve nearly circular, moderately convex, the greatest convexity being about one-third the distance from the beak to the front part of the shell, umbo depressed. Ventral valve much more convex, and the beak produced beyond that of the dorsal valve, and strongly recurved.

The only specimen we have seen of this fine shell is an internal cast, with a fragment of the test adhering to the beaks. Traces of ten or twelve broad shallow plications can be seen on the front portion of the shell, two or three of which probably extended to the beak on the ventral valve, while the others became obsolete before reaching the cardinal border. Traces of fine longitudinal striations are also visible with a good glass. Length from the beak to the front 23, breadth 22, heighth 14 millimeters.

Dedicated to the memory of Mr. Wm. Gifford, of Peoria county, Ill., from whom the specimen was received.

Position and locality: Middle Coal Measures near Alta, Peoria county, Ill.

Illinois State collection.

LAMELLIBRANCHIATA.

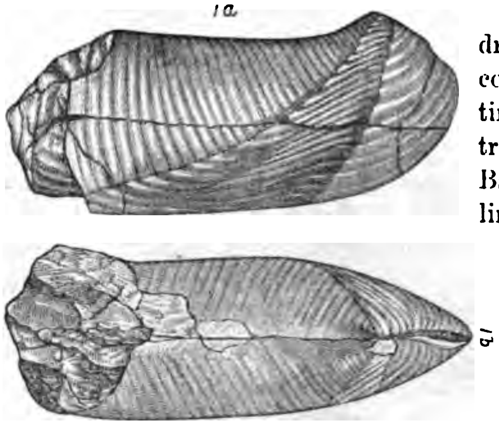
GENUS CHÆNOMYA, Meek.

CHÆNOMYA MARIA, Worthen.

a Side view. *b* Dorsal view, nat. size.

Chænomya Maria, WORTHEN, February, 1882.

Bulletin No. 1, of the Illinois State Museum of Natural History, p. 39.



Shell elongate, sub-cylindrical, anterior side much compressed and aperture entirely closed; posterior side truncated and widely gaping. Base slightly convex in outline, rounding up gradually in front and abruptly behind, dorsal side a little concave from the beaks to the posterior extremity. Beaks depressed, incurved, and located about one-fifth the entire length of the shell from the anterior side.

Two conspicuous furrows commence at the beak, the anterior one crossing the valve obliquely to the base of the shell at a point about two-fifths of its entire length from the anterior side; the posterior one crossing the shell much more obliquely, and terminating at the base of the shell, near its posterior extremity.

In addition to these furrows each valve is marked by about thirty-two longitudinal ridges that are a little wider than the spaces between them. These commence at the dorsal margin near the beak, and when they cross the posterior furrow already described, they are deflected abruptly forward to a right angle with their former course, about two out of every three ending at the anterior furrow, while the others are continuous across that to the anterior border of the shell.

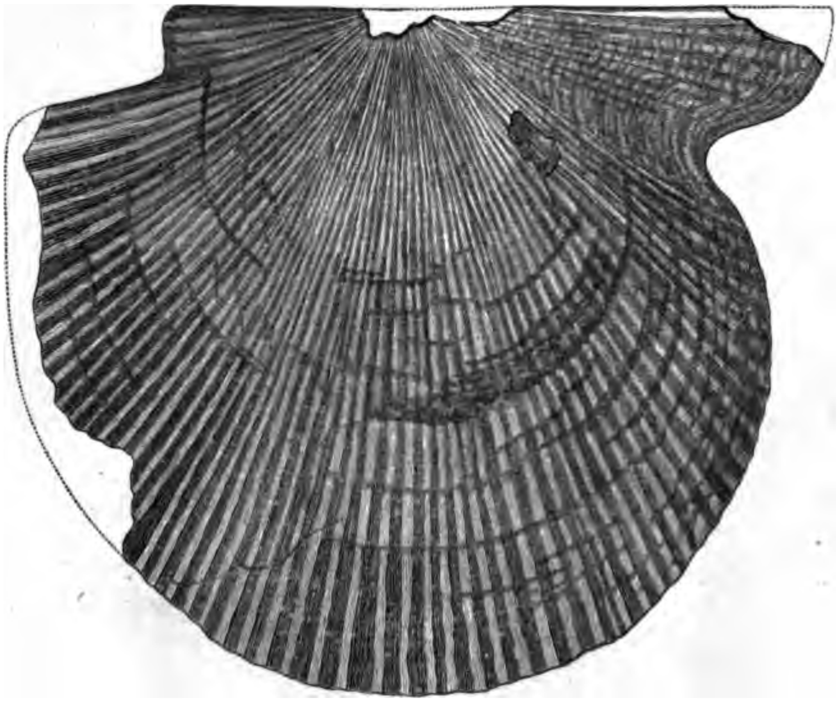
A small fragment of the shell, attached to the cast, shows that the surface was finely striated obliquely from the beak to the front, and with a good lens the striæ are seen to consist of rows of minute granules.

Dedicated to Mrs. Orestes St. John, by whom this fine specimen was discovered, and to whom I am indebted for the use of it.

Position and locality: Upper Coal Measures, Shawnee county, Kan.

GENUS AVICULOPECTEN, McCoy.

AVICULOPECTEN VARSOVIENSIS, Sp. nov.



View of left valve, Natural size.

Shell large, suborbicular, hinge-line rather shorter than the greatest breadth of the valves below. Left valve nearly flat, posterior ear short, and forming a rather acute triangle, which is clearly defined from the posterior margin below.

Anterior ear nearly twice as long as the posterior, not so distinctly angular in outline, the outer margin curving into a deep indentation where it joins the lateral border of the shell. Both ears show traces of raised lines or costæ, corresponding to those on the body of the shell, and on the anterior ear, faint transverse lines of growth are visible.

Surface of the valves marked by numerous raised lines or costæ, that increase towards the base by implantation, and are about as wide as the spaces between them. From 80 to 90 of these costæ may be counted on the borders of the shell.

Greatest width of the valves 4 inches. Length from beak to base $3\frac{7}{16}$ inches. Length of hinge-line $3\frac{1}{2}$ inches.

Locality and position: Upper beds of the Keokuk limestone, near Warsaw, Ill. The author's collection.

This is a very rare species, only one valve, and part of another, having been found in 25 years collections from this horizon.

DESCRIPTIONS OF SOME NEW SPECIES OF FOSSIL SHELLS

FROM THE

LOWER CARBONIFEROUS LIMESTONES

AND

COAL MEASURES OF ILLINOIS.[1]

By A. H. Worthen.

Orthoceras Illinoiensis, Sp. nov.

Shell of medium size, gradually enlarging from the apex; section slightly ovate, siphuncle rather large, and placed near the margin of the shell.

Septa moderately convex and oblique to the axis, being arched strongly upward about twice their width on the siphuncular side, and equaling in width about one-fifth of the shortest diameter of the shell. Surface markings unknown.

Length of the largest specimen seen, about 6 inches; greatest diameter of the outer chamber, 2½ inches; greatest width at the apex, ⅞ inch.

This rare shell is only known from three imperfect specimens obtained from the upper limestone at Chester.

No. 2,484, of the Illinois State collection.

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[1] Note. These brief descriptions are published with the hope that the species may be properly illustrated in a subsequent volume of these reports. The originals, all of which belong to the State Museum of Natural History, will be found properly catalogued in the cases of the Museum, where they will be accessible to those who may desire to compare them with similar forms from other localities.

ORTHOCERAS OKAWENSIS, Sp. nov.

Shell elongate, slender, very gradually tapering to the apex; septa concave, about 4 of them usually in the space of one diameter. Siphuncle subcentral, surface markings unknown.

This shell has a general resemblance to *O. Rushensis* of the Upper Coal Measures, but differs from that in the position of the siphuncle, which in our species is decidedly subcentral.

Position and locality: Chester limestone, vicinity of the Okaw bluffs, near Red Bud, Randolph county, Illinois.

No. 2,485, of the Illinois State collection.

ORTHOCERAS LASALLENSIS, Sp. nov.

Shell small, gradually tapering. Surface ornamented with transverse ridges or elevations; situated at irregular distances from each other, and with delicate thread-like striæ which cover the transverse ridges as well as the spaces between them. The ridges and striæ will serve to distinguish this species from any hitherto found in the Coal Measures, its ornamentation resembling that of the *O. undulatum* of the Niagara limestone more closely than any other known American species. The fragment preserved seems to belong to the non-septate portion of the shell.

Position and locality: Roof of the middle coal, LaSalle, Ill.

No. 2,486, of the Illinois State collection.

PLEUROTOMARIA MONTEZUMA, Sp. nov.

This fine shell is only known from an imperfect cast of the last whorl, which may be described as follows:

Shell attaining a large size, broadly conical in outline; whorls three or more, rapidly diminishing in size towards the apex. Last whorl obliquely flattened, showing a surface about two inches in breadth, which is traversed by about eight rather strong revolving striæ, separated by shallow depressions that are about ⅜ of an inch wide near the aperture. The under side of this whorl was also traversed by numerous revolving striæ, about half as far apart as those on the upper side, but their number can not be fully determined by the specimen in hand. A raised line around the inner side of the whorl indicates the presence of a rather wide and deep umbilicus.

Greatest width of the specimen in hand, 4⅝ inches; height of the outer whorl, 1⅛ inches.

Position and locality: The only specimen seen was obtained at Montezuma, Pike county, Illinois, from near the base of the Burlington limestone.

No. 2,487, of the Illinois State collection.

Dentalium Illinoiensis, Sp. nov.

Shell above the medium size, long, straight cylindrical, slightly tapering, and scarcely inflated at the aperture. Surface originally smooth, but slightly roughened from weathering in the specimen under examination.

Length, 5⅞ inches; width near the aperture, 7-16 in.

This species differs from *D. Missouriense* of Swallow, in its larger size, smooth surface and straight form.

Position and locality: Lowest beds of the Chester limestone, Chester, Illinois.

No, 2,488, of the Illinois State collection.

Conularia Chesterensis, Sp. nov.

Shell attaining a medium size, long and rather slender, gradually tapering, nearly equally four sided, the four angles being distinctly and rather deeply furrowed, while a slight furrow marks the median line on each side. The sides are crossed by numerous raised costæ, which arch slightly forward from the angles to the median line, making an angle with that line of about 14°. They do not cross the angular furrows, but are alternately arranged so that those on one side terminate at the intervening space between those on the opposite side. These spaces are about twice as wide as the costæ, and are widest at the median line.

The aperture is not well preserved in any of our specimens, but the shell was notched at the angles and probably contracted at the aperture.

Length of a rather large individual, 5 inches; breadth between the angles near the aperture, 1 inch; number of costæ in the space of an inch near the aperture, 20; near the apex, 30.

Position and locality: Chester limestone, Chester, Illinois.

No. 2,489, of the Illinois State collection.

PINNA ST. LUDOVICI, Sp. nov.

Shell comparatively short, lanceolate; length about twice as much as the greatest width. Section ovate-elliptical, valves traversed longitudinally by about twelve to fifteen rather strong ribs that are most prominent on the middle portion of the shell, and become obsolete towards the vental and dorsal margins. Spaces between the ribs narrow, beak unknown. Angle formed by the dorsal and vental margins about 40°.

This rare species is only known from a single specimen preserved in chert, with both extremities wanting. It may be readily distinguished from *P. Missouriensis* of the Chester group, and from any other species known in our Carboniferous rocks, by its shorter form and greater proportional width.

Position and locality: St. Louis limestone, Monroe county, Ill.

No. 2,490 Illinois State collection.

CYPRICARDIA? RANDOLPHENSIS, Sp. nov.

This shell is only known from some casts in limestone, which may be briefly described as follows:

Shell oblong, height from the beak to the ventral margin about half the length, valves moderately convex on the anterior portion of the shell, and depressed towards the posterior end, where the valves were apparently closely joined. Beaks rather large, depressed and incurved beyond the dorsal margin, and situated about two-fifths the distance from the anterior to the posterior extremities. A broad and slightly flattened depression appears on some of the casts, extending from the beak to the ventral margin of the shell. Dorsal margin nearly straight, ventral margin parallel with the dorsal for about two-thirds of its length, curving abruptly upward on the anterior, and more gently on the posterior end. Lunule ovate; surface markings unknown.

Length of an average specimen, 2⅝ inches; height, 1⅜ inches; thickness, 15-16 inch.

Position and locality. Chester limestone, Randolph county, Ill.

No. 2,491 Illinois State collection.

Descriptions of new Carboniferous Echinoderms, by A. H. Worthen and S. A. Miller.

CLASS ECHINODERMATA.

ORDER ASTEROIDEA.

FAMILY PALÆASTERIDÆ.

COMPSASTER, n. gen.

(Ety. *Kompsos*, elegant; *aster*, a star.)

Body stellate; central area or disc comparatively small; rays large, long, more or less fusiform; grooves deep and bordered by numerous thin, subcircular, adambulacral plates. The ventral side of the typical species shows about six rows of plates upon each side of the ambulacral furrows, which have a regular, transverse, as well as longitudinal arrangement.

This genus is distinguished from all others in the family by the number and form of the adambulacral plates, by the great number of disc plates upon each side of the ambulacral furrows, and by the general form of the body and rays.

COMPSASTER FORMOSUS, Sp. nov.

Pl. XXXI: Fig. 2 *a*, ventral side, natural size; fig. 2 *b*, section of a ray enlarged two diameters.

Body deeply stellate; central disc comparatively small; rays rigid, large, fusiform, more than twice as long as the diameter of the central disc, and terminating abruptly in an obtuse point. The typical specimen furnishes the following measurements: Diameter of the body, $\frac{72}{100}$ inch; length of ray from central part of disc, 1.$\frac{78}{100}$ inches; diameter of the ray at its junction with the body, $\frac{41}{100}$ inch.

Ambulacral grooves deep; ossicles rather small; adambulacral plates very numerous, and consisting of a series of thin plates upon each side of the ambulacral furrows, which are rounded upon the exterior, prolonged below, and each bear a short, sharp spine on the upper part of the inner side, directed toward the apex of the ray. There are about eighty adambulacrals upon each side of the furrows, and they diminish very slowly in size toward the apex, after passing the fusiform enlargement of the ray.

The disc-plates abut upon the adambulacrals in a straight line; they are subquadrangular, or polygonal, and each bears a short, strong central spine. Six longitudinal rows appear on the ventral side on each side of the ambulacral furrows; they are somewhat uniform in size, arranged in transverse, as well as longitudinal order, and are about two-thirds as numerous in a longitudinal row as the plates in an ambulacral series.

Oral plates, madreporiform tubercle, and dorsal side unknown, except so far as we may judge of the spinous character of the plates from those visible on the ventral side.

This large and beautiful species is so distinct from any hitherto described, that no comparison is necessary for the purpose of identification.

Position and locality: Okaw bluffs, between Chester and Kaskaskia, Randolph county, Illinois; from the second division of the Chester limestone.

Illinois State collection of 1880, by A. H. Worthen, No. 2,476.

CHOLASTER n. gen.

(Ety. *cholos*, defective; *aster*, a star.)

Body truncated pentagonal, central area circular, deep and large in proportion to the rays; rays distant, small, short and abruptly truncated.

Dorsal side possessing a rather large centro-dorsal plate, which is surrounded by five plates occupying the position of radials, while the other part is covered with numerous small disc plates.

This genus being founded on a specimen showing the dorsal side only, further particulars will be found in the definition of the species. This fossil is so widely different from those heretofore discovered that we think it belongs to a distinct family, which might, very appropriately, be designated the *Cholasteridæ*, but until other specimens have been found showing other parts of the body, we prefer to let the family remain undefined.

CHOLASTER PECULIARIS, Sp. nov.

Pl. XXXI. Fig. 4. *a.* Dorsal view, natural size; *b.* Section of a ray enlarged, showing the arrangement of the plates.

The general form of the body is that of a truncated pentagonal star, with a large circular disc. A centro-dorsal plate is surrounded by five others, all of which are much larger than other plates of the body, and occupy a centro-dorsal depression. The position of these five plates is that of radials, resting upon a basal, and therefore, all other plates of the body might be regarded as radials and interradials, the latter being very numerous, because of the wide separation of the rays at their junction with the body. The interradials are polygonal, convex, or subspinous plates, without much variation in size whether filling the larger or smaller interradial spaces. The plates following the larger radial plates, as above defined, in the direction of the rays, are not, however, by their form or arrangement to be distinguished from the interradials, though differing from those forming the rays. The plates covering the dorsal side are thus divided into three kinds, viz.: First, the larger plates filling the centro-dorsal depression; second, the disc plates which cover all other parts of the body except the rays, and, third, the plates which cover the rays proper, which in this species are easily distinguished from the central disc plates.

The rays are short, abruptly truncated, and slightly expanded at the apices by reason of an enlargement of the terminal plates. They are widely separated from each other, though not at uniform distances, and present the appearance of having been stuck on the central disc, instead of having grown from it, an appearance more marked, by reason of the change in the form of the plates, from the disc to the rays.

One of the interradial spaces is much greater than the others, so that a line may be drawn across the disc, leaving three entire rays upon the smaller half. The back of each ray is covered by a series of transversely elongated plates separated from the side series by a longitudinally impressed line. A single series of plates covers either side of a ray, interlocking with the transverse dorsal series and directed backward toward the disc.

The oral plates are unknown, and no madreporiform tubercle has been detected.

Position and locality: Same as the last.

No. 2,480 Illinois State collection of 1880.

ORDER OPHIUROIDEA.

TREMATASTER, n. gen.

(Ety. *trema*, an opening; *aster*, a star.)

Body stellate, central part discoid, rays long, flexuous and gradually tapering. Rays consisting of a double series of ambulacral plates, forming, together, a subcuneiform series with the tapering ends directed toward the apices of the rays and uniting with the larger ends of the succeeding double plates, upon each side of which there is a series of curved adambulacral plates, which form the margins of the rays. The pores are large and situated between the contracting sides of the ambulacral plates and the concave sides of the curving adambulacrals. Four plates border upon each pore though nearly surrounded by two of them. Plates ten. Dorsal surface unknown.

This genus is distinguished by the parallel arrangement of the ambulacrals and adambulacrals, instead of the alternate order, and by the large pores.

TREMATASTER DIFFICILIS, Sp. nov.

Pl. XXXI, fig. 3, a, ventral side magnified two diameters, fig. 3, b, section of a ray showing the arrangement of the plates magnified four diameters.

Body stellate, disc small, rays long, flexuous and gradually tapering.

Ambulacral plates subtrigonal, elongated, and united upon their straight faces in parallel order, so as to form a series of subcuneiform sections at the bottom of the ambulacral groove, with the tapering end of each directed toward the apex of the ray, and uniting with the larger end of the next succeeding double plate.

Adambulacral plates parallel with the ambulacrals, and each forms a curve from the larger end of an ambulacral toward the apex of the ray, to unite with the next succeeding adambulacral as it curves away from its attachment to the ambulacral. By this order of construction the adambulacrals are fixed, at one end, to the ambulacrals, while the other end moves upon the curved surface of an adambulacral so as to allow the same lateral flexibility of the rays, secured in other genera by the alternate arrangement of the plates.

The pores are large and situated between the contracting sides of the ambulacral plates, the concave sides of the adambulacrals, and the attaching ends of the succeeding plates, so that they are bounded by four plates while nearly surrounded by two.

The oral plates form, in pairs, elongated triangles, with the acute angle directed toward the center of the visceral cavity. The apices are joined by a suture with the basal portions, which are partly separated by a dividing furrow. A single genital pore perforates each basal section of the oral plates. Dorsal side unknown.

Locality and position: Prairie du Long creek, Monroe county, Chester limestone.

No. 2479, Illinois State collection of 1878.

ORDER PERISCHŒCHINIDÆ.

FAMILY LEPIDECHINIDÆ.

HYBOCHINUS, n. gen.

(Ety *hubos*, hump-backed; *echinus*, the sea urchin.)

Test flexible subspheroidal, and consisting of five (?) ambulacral, and the same number of interambulacral areas. Ambulacral areas composed of numerous ranges of interlocking and overlapping plates, each of which is perforated in the central part, by a single pair of pores. The plates imbricate from below upward. Interambulacral areas narrower, and consisting in the equatorial region of five or more ranges of overlapping plates some of which disappear before reaching the poles. The plates imbricate from above downward and from the central range outward. Surface covered with small granules—not large tubercles—for the articulation of minute spines. Jaws consisting of large, subtriangular, truncated conical pieces, deeply furrowed towards the ends, and perforated in the central part.

This genus is related in many respects to *Lepidesthes*, but differs in the important particular of having the imbrication of the plates in the opposite direction, as in the *Echinothuridæ* or more modern family of flexible *Echinoids*. The humps and protuberances of the upper end of the type specimen, which suggested the generic name, are supposed to indicate the great flexibility of the test, and an abnormal development of the number of ambulacral plates. An abnormal development of the plates in *Lepidesthes*, however, could not produce such protuberances at the apical end, because the imbrication of the plates is downward and would not permit it. Had we other specimens showing an irregular development of the ambulacral areas and great increase in the number of plates towards the apical end, we would couple this feature with the remarkably developed jaws, and refer the genus to a new and distinct family under the name of *Hybochinidæ*. At present we leave it in a family where it seems to have at least some affinity. It is quite unnecessary to compare it with any other genus, or for the purposes of identification to continue the comparison with other characters possessed by *Lepidesthes*.

HYBOCHINUS SPECTABILIS, Sp. nov.

Pl. XXXI. fig. 5 a.; view of a depressed specimen as it appears on a slab, showing parts of four ambulacral, and three interambulacral areas, a peculiar horn-like protuberance and the protrusion of the jaws; fig. 5. b., view of the interambulacral plates and two ranges of ambulacrals on each side near the apical end, magnified two diameters, some of the scattering spines from the interambulacrals are also indicated; fig. 5. c., magnified view of the ambulacral or other plates as they are thrust out in the horn-like protuberance; fig. 5, d., magnified view of some of the ambulacrals and adambulacrals; fig. 6, summit of a crushed specimen showing the jaws; fig. 7, jaws that may belong to this, or a kindred species.

General form subspheroidal, modified, however, by the extreme flexibility of the test, and as it appears, in the type, at the apical end, by peculiar protuberances, one of which projects like a horn. Ten ranges of plates may be counted in an ambulacral area in the type specimen, but this number may be, and probably is, exceeded in the equatorial region, for ten ranges may be distinguished in the horn-like projection from one of them, where all the ranges are certainly not exposed. The ambulacral plates imbricate from below upward, each exposing a somewhat regularly hexagonal area, transversely elongated, in the central part of which there are two pores. As the plates imbricate upward the lower part of each is covered, so that, in fact, the pores occupy an upper central position in each plate, passing through at the lower inner edge of the succeeding one. The plates are so beveled as to form a smooth exterior to the body. The interambulacral areas are lanceolate, a little more than half as wide as the ambulacral areas, and consisting, as shown in our specimen, at a point above the equatorial region, of five ranges of plates. The ranges decrease in number toward the poles, and the plates slightly diminish in size. The plates imbricate downward, and from the central range outward, so that they overlap the ambulacral plates upon either side. The exposed surface of each plate is quadrangular, and usually square, or nearly so. The surface is covered with small granules for the articulation of minute needle-like spines, the articular ends of which are marked by a slight swelling. The jaws are remarkably large, and seem to have formed an ovate body of ten or twelve pieces, each of which is deeply furrowed at the ends, and perforated in the central region.

Other openings and characters of this species cannot be correctly defined from our specimens. Those represented by figures 5 and 6 show only the crushed apical regions and the parts described, and were collected from the Chester limestone on Prairie du Long creek, in Monroe county, by A. H. Worthen. The one represented by fig. 7 was obtained from the same horizon in Pope county, and may or may not belong to this species. The jaws seem to be smaller than they are in the other two specimens, but this may result from their being more fragmentary. One genital plate, however, appears upon this specimen having four pores, and if it belongs to this species it will of course add that additional character.

No. 2,481. Illinois State collection.

Genss PERISHODOMUS, McCoy.

Perischodomus Illinoiensis, Sp. nov.

Pl. XXXI. fig. 8, view of the apical end of a distorted specimen, natural size.

General form apparently subspheroidal, and as there are five ambulacral and five interambulacral areas, and the former are so narrow, it probably has a subpentagonal outline as noticed by McCoy in diagnosing the genus.

Ambulacral areas narrow, depressed, over-lapped on either side by interambulacral plates, and consisting of a double series of interlocking transversely elongated plates, each one of which is pierced by a single pair of pores. These plates are not uniform in size nor shape, though most of them seem to have imperfectly defined subpentagonal outlines. They slightly overlap from above downward.

Interambulacral areas covering nearly the entire surface, but as the equatorial region is not preserved, it is impossible to state the number of ranges of plates in each area. There may be five and there may be seven only five can be distinctly determined from the apical view of our specimen. The plates are very irregular in size, imbricate upward, and the two rows adjoining the ambulacral areas imbricate outward, but whether the imbrication is from the central range outward, as is usual in such cases, cannot be determined, for the central range seems to be depressed, which may have resulted from the crushing the fossil has received.

The plates bore two kinds of spines; those bearing the larger kind possessed a single central spine, but those bearing the smaller kind possessed two or more submarginal ones. The central supporting tubercle is a moderately large smooth hemispherical nipple with a central perforation. Only one plate of this kind is shown upon the typical specimen, and it is in the second range from the ambulacral area at about the sixth plate from the genitals. The secondary spines were borne by both rows of plates on each side of the ambulacrals, as indicated by small, more or less conical elevations, some of which show a minute perforation, and indeed may have been borne by the plates in the other ranges. Other characters of the species unknown.

The plates, in the interambulacral areas of this species, correspond in number, order of arrangement, and spinous character so much more nearly with *Perischodomus* than with *Lepidechinus*, the most nearly approximating genus in other known respects, that we have little doubt of the correctness of the generic reference, though it would be unnecessary to point out how it differs from the European forms for the purpose of specific distinction.

Collected by A. H. Worthen from the Chester limestone at Bay City, Pope county, Illinois.

No. 2,483 Illinois State collection.

ORDER AGELACRINOIDEA.

FAMILY AGELACRINIDÆ.

ECHINODISCUS, n. gen.

(Ety. *echinus*, sea urchin; *diskos*, a round plate.)

Body discoid, depressed convex, the smaller plates being found in the border and ambulacra adjacent thereto, and the larger plates occupying the central part of the interradial spaces, none of them imbricating. The border consists of narrow plates elongated in the direction of the circumference, and passing around upon the under side, forming a cylindrical nonsessile rim. Ambulacra five, connected near the central area, but not arising from a common point, consisting of narrow, curving angular arches, sharply defined on either side, and composed of numerous interlocking or dove-tailing plates. Mouth or ovarian pyramid central or subcentral.

This genus is distinguished from *Agelacrinus*, with which it seems to be most nearly related, by many important characters. *First*, it is not composed of imbricating plates. *Second*, the manner of attachment to other objects was different, as in this genus the margin was free. *Third*, the ambulacra do not arise from a pyramidal elevation or common point, but, one may be said to arise on one side of the mouth, and to connect, by an ambulacral series of plates, with the points, at which two arise, on either side of it, or that two series bifurcate, if it is considered that three series originate on one side of the mouth, in the first instance. *Fourth*, the mouth or ovarian pyramid is subcentral, while in *Agelacrinus* it is submarginal. This elevation would seem to be homologous with the mouth in the echinoids, for below it, within the visceral cavity, there occur several pieces, which were evidently connected with the digestive functions, and therefore homologous with the jaws in the latter order.

ECHINODISCUS OPTATUS, Sp. nov.

Pl. XXXI. Fig. 9. view of part of the lower side of a specimen showing the plates near the margin.

Body discoid, rather large, being more than an inch in diameter, and having large plates in the interambulacral areas, and smaller ones on other parts of the test. The margin is composed of small plates elongated in the direction of the circumference, and forming a semi-cylindrical or rounded rim, but not attaching to other objects, showing that if the species was sessile it did not unite by the whole underside, as in *Agelacrinus.*

Interambulacral areas depressed, concave, covered with polygonal plates, those in the central part large, while those in the margin are smaller, and appear as if trimmed to a straight edge for the reception of the ambulacra.

The ambulacra are long, slender, curving, angular arches, set within the face of the disc, and joined with the interambulacral plates by straight lines, without interlocking or imbricating plates. They are composed on each side of alternately longer and shorter plates which interlock at the angular arch, with each other and with smaller intercalated plates, so as to give a zigzag outline to the dovetailing union of the plates on the surface of each ambulacrum. The ambulacra do not arise, as in *Agelacrinus*, from a central pyramid, but the divisions take place near the central part of the disc, separated by numerous ambulacral plates, and on different sides of the mouth. The manner of bifurcation may be described in this way: a division takes place on one side of the mouth, from whence two ambulacra curve over the face of the disc, and an ambulacral series of plates is directed past the mouth; at the distance of one-tenth of an inch it throws off, in the direction opposite the mouth, a curving ambulacrum and continuing to pass the mouth, at the distance of another tenth of an inch it divides into two ambulacra. This leaves the mouth in the wider interambulacral area.

The mouth would seem, from the condition of our specimens, to be central, but it may be slightly subcentral. It consists, on the exterior, of an elongated elevation covered by numerous plates of larger and smaller size, which are supported on the interior by a fewer number of plates, some of which are fluted, but the exact order, arrangement and purposes of which are not determined.

Collected by A. H. Worthen from the Chester limestone in Monroe and Pope counties.

No. 2,478, Illinois State collection.

ARCHÆOCIDARIS EDGARENSIS, Sp. nov.

Pl. XXX, Fig. 15. a. b. c.

Primary spines long, gradually tapering, cylindrical; articulating end perforated with a round aperture, and enlarged in a space of about a quarter of an inch into a strongly striated ring, from which it rapidly decreases above to its normal diameter at the articulating extremity. The upper portion of the primary spines for about three-fourths of their entire length are rather thickly set with short lateral spinules, that project upwards towards the extremity of the spine, where the latter terminates in a mucronate point.

Interambulacral plates hexagonal, length and breadth nearly equal, with a single row of granules on the rim of the smaller plates, while on the larger ones two or more rows of small granules may be seen.

This species bears some resemblance to *A. mucronatus*, Meek and Worthen, described and figured in Volume 2 of these reports, page 295, Pl. 23, fig. 3, a. b. c. That species was obtained from the Chester limestone, and the *A. Edgarense* may be readily distinguished from that by its shorter and more numerous spinules, its strongly striated ring, and the less robust character of its primary spines.

Position and locality: Upper Coal Measures, one mile east of Baldwinsville, Edgar county, Ill.

No. 2,447, Illinois State collection.

ARCHÆOCIDARIS SPINO-CLAVATUS, Sp. nov.

Pl. XXX, fig. 14. *a, b, c, d, e*, and Vol. 5, Pl. XXIV, fig. 13, *a, b, c, d, e*

Primary spines rather long, moderately stout, cylindrical at the base and gradually increasing in diameter toward the upper extremity to twice or three times the diameter below, and then rapidly diminishing to an obtuse termination.

The enlarged upper portions of the spines are sometimes subtriangular in section and thickly covered with nodose spinules, which are longest on the angles, and directed upward toward the apex of the spine. These nodose spinules continue down over the middle portion of the spine, but they are smaller and less numerous than on the clavate portion above. The lower part of the long spines are nearly or quite destitute of spinules, but on the shorter ones they continue nearly to the basal ring. This ring is nearly twice the diameter of the articulating extremity, and smooth.

Interambulacral plates hexagonal, with a nodose rim around their margins, and there are indications of low granules scattered sparingly over the outer surface of some of them, but they are highly silicified, and their external markings thereby obscured.

Central tubercle strongly elevated, papilliform, with a rather deep space between it and the annulation, the latter forming a distinct and slightly projecting rim for its support.

This species may be readily distinguished from other Coal Measure species by the spino-clavate character of its spines.

Position and localities: Middle and lower Coal Measures, St. Clair and Marshall counties, Illinois.

No. 2,404 Illinois State collection.

ARCHÆOCIDARIS ILLINOIENSIS, Sp. nov.

Pl. XXXI, Fig. 1, a. b.

Primary spines rather stout, cylindrical, tapering very gradually above the articulating ring to their extremities. Articulating ring subangular, and from this the spines contract rapidly to the articulating extremity. Just above the articulating ring the spines are slightly curved, and above the curvature they are studded with short sharp spinules that are directed outward and slightly upward towards the extremity of the spine. The articulating end is perforated by a round aperture, which extends about to the articulating ring.

The only specimens of this species yet obtained consist of primary spines, and some fragments of the inter-ambulacral plates, the latter too imperfect for an accurate description.

Position and locality: From the black beds of the St. Louis limestone, near the Illinois Furnace, Hardin county, Illinois.

No. 2,475, of the Illinois State collection.

PALÆONTOLOGY OF ILLINOIS

SECTION III.

DESCRIPTION OF FOSSIL INVERTEBRATES.

By Charles Wachsmuth
and
W. H. Barris.

PALÆOCRINOIDEA.

GENUS ALLAGECRINUS, Carp. and Ether.

ALLAGECRINUS CARPENTERI, Wachsmuth.

Pl. XXIX. Fig. 14.

Allagecrinus Carpenteri, WACHSMUTH, February, 1882.

Bulletin No. 1, of the Illinois State Museum of Natural History, p. 40.

The unique specimen upon which this species is founded is from the collection of Prof. Worthen, who kindly permitted me to describe it. It is partly imbedded in the rock, but only a small portion is covered by the matrix. It consists of a two-inch column, the calyx and arms. The calyx is somewhat pressed out of shape, but with this exception is excellently preserved. The specimen is small, its length measuring from the basal disk to the tips of the arms 80.100 parts of an inch, to the arm bases 16.100 parts, of which the basal disk occupies only 4.100 parts.

Specific Diagnosis: The calyx is of small size, the form is cylindro-conical; it is composed of two rings of plates, the upper supporting the arms. There are no interradials, and no azygous side. Plates strong, without ornamentation.

Basal disk undivided, at least without visible suture lines; it is short, three times wider than high, saucer-shaped the upper side but little wider than the bottom part, with very obtuse upper angles.

Radials 1x5, differing somewhat in width, wider at the top, quadrangular in outline, but actually pentangular; axillary, with very obtuse upper angles, the sloping sides slightly excavated and supporting the free arms.

Arms two from each ray, simple throughout, unequal in size, some of them one-half thicker than others—not tapering; nearly as thick at the distal end as at the base. The arms are constructed of from eight to ten simple joints, the first joint one-half higher than wide, and differing from the others by being flattened at the dorsal side, all succeeding ones rounded at the outer side, with slightly expanded ends; upper and lower sides almost parallel. The length of the joints is somewhat irregular, varying from three to four times their width, but in proportion to the width of the arm; ventral groove wide and deep. No pinnules have been observed, and the construction of the vault is unknown.

Column circular very strong at the basal disk, but tapering so rapidly in its course downward that at about one-fourth of an inch it is reduced to less than one-third its greatest width, whence it remains stationary as far as it is preserved in the specimen. The segments of the upper or conical part are short, sharply edged, and of the same height, but as soon as the column attains its ordinary size, the joints become abruptly higher, more cylindrical, and thicker and thinner joints alternate in the usual way. Central perforation small.

The specific name is given in honor of P. Herbert Carpenter, Assistant Master at Eaton College, England, one of the founders of the genus *Allagecrinus*.*

Geological position, etc: From the Chester or Kaskaskia limestone, Monroe county, Illinois.

Illinois State collection.

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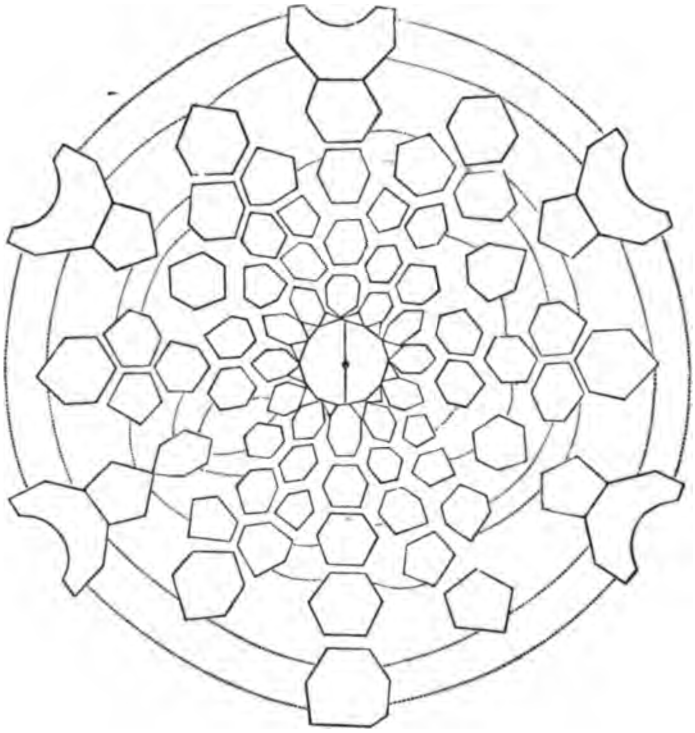
*The genus was proposed by P. Herb. Carpenter and Dr. R. Etheridge, jun., for a small species from the Carboniferous of Scotland. (Annals and Magazine Nat. Hist., April 1881, p. 281.

GENUS ACROCRINUS, Yandell.

ACROCRINUS WORTHENI, Wachsmuth.

Pl. XXX, Fig. 13.

Acrocrinus Wortheni, WACHSMUTH, February, 1882.
Bulletin No. 1, of the Illinois State Museum of Natural History, p. 40.



Anal plates.
Diagram illustrating the structure of the genus *Acrocrinus*.

This species is described from a single specimen, of which only the calyx is preserved; the vault, the arms and the columns are so far unknown. The calyx, however, is in excellent preservation, and, notwithstanding its small size, exposes plainly every plate. The form is calyculate, broadly truncate at the bottom, abruptly bending upward toward the base of the first radials, whence it gradually decreases in width to the arms. Its length is 40.100 of an inch, its greates width 42.100, the width at the arm bases 34.100. The plates are plain, without ornamentation, but sufficiently convex to point out the sutures.

The genius *Acrocrinus* departs from most Palæocrinoidea in two important points. The plates of the calyx, which in all species with a large number of plates decrease in size from the basals to the top of the calyx, in *Acrocrinus* decidedly increase in the same direction. Another striking departure is that the radials are not connected with the basals, and partly not even among each other, but are separated by several rings of plates, which in their position are partly radial, partly interradial, and which have apparently no representation in other genera of the Palæocrinoidea.[†]

The specimen under consideration is composed of 86 plates, some of them extremely minute. There are two comparatively large basals, equal in size, the suture passing from the anterior to the posterior side, which together form a concavity within the truncate part of the calyx. The basal disk is surrounded by a ring of twelve very small triangular pieces, and these in turn are succeeded by a second series of seven plates each, arranged like the former, occupying the azygous side, and are separated, in place by radials, by a row of four hexagonal special anal plates, which, with the exception that the upper side of the upper plate is not excavated, have exactly the form and size of the four radial plates at the anterior ray. This ray has exceptionally four radials, hexagonal like the anals, which, with their truncate side, are connected among each other, and with the heptagonal piece of the second ring heretofore described. The four lateral rays not only consist of but three plates, but these radials have also a very different form, and are partly disconnected. The first is hexagonal, with upper and lower sides angular, the second pentangular, angular below. Only in a single ray of the specimen do the angles of the two plates touch each other; in the four others they are separated by plates from different interradial areas, which join here, there suture forming a line between the angles of the two radials. The first and second radials are all connected by a truncate side. The third radials are one-half wider than high, hexagonal, contrary to the first and second, which are a little higher.

[†] They may have in some genera a representation in the vault, in which to some extent the plates of the calxy are repeated. Here the representatives of the basals and radials are frequently separated by one or more rings of intercalated pieces. These vault pieces increase in number by age, and are often entirely absent in young specimens or in small species of the genus, being here evidently a product of growth. In *Acrocrinus* one of the latest genera of the Palæocrinoidea, the intercalated plates in the calyx may have a similar origin, but are here evidently not mere individual growth, but have become a fixed character.

The interradials of the four lateral rays, toward the anterior side, consist of seven plates in four series, 2, 2, 2, 1; at the anterior side of only six pieces, 2, 1, 2, 1. The plates of the first series rest with their lower sloping sides against two of the intercalated pieces—those composing the second ring around the basals; they are placed with their lateral side against the sides of their fellows of the adjoining interradial area, except toward the anterior and posterior side, where they abut, at the former against the first radial, at the latter against one of the special anal plates. The plates of the succeeding series rest with their outer sides within the angle between two radials, with the other side against the adjoining interradials. The plates of the interradial areas are either hexagonal or pentagonal, and their increase in size in an upward direction is even greater in that same direction among the radials, the upper one being fully three times larger than the two interradials of the first series. The same is true with regard to the azygous side.

The anal side is very wide, and is composed of a median row of four hexagonal pieces, longitudinally arranged, and of a series of seven plates at each side of it. The latter are arranged like the seven plates of the two interradial areas adjoining the anterior ray, and as the radials of that side, as already stated, are arranged and constructed like the special anal plates, the anterior side, with its two interradial series, is almost a perfect counterpart of the anal area. The uppermost anal plate is hexagonal or, perhaps, octagonal, its upper side truncate; its size is equal to, if not larger than, that of the first radials.

Acrocrinus Wortheni differs from the two previously described species of this genus most conspicuously in the form of the basal plates. The construction of the other plates is so imperfectly known that a comparison of other parts is impossible. There is also a great difference in the form of the body.

The specific name is given in honor of Prof. A. H. Worthen, the able director of the Illinois geological survey.

Geological position and locality: From the Coal Measures of Peoria county, Ill.

The type is in the Illinois State collection.

ON A NEW GENUS AND SPECIES
OF
BLASTOIDS,
WITH OBSERVATIONS UPON
THE STRUCTURE OF THE BASAL PLATES IN CODASTER AND PENTREMITES.

BY CHARLES WACHSMUTH.

Among some interesting new Blastoids, lately sent to me for investigation by Rev. W. H. Barris, of Davenport, Iowa, collected by him in Northern Michigan, I found one type, which seemed to me of unusual interest as representing a form intermediate between *Codaster*. McCoy, and the new genus *Phænoschisma*, Ether. and Carp. At my request, Mr. Barris not only kindly permitted me to describe the species, but he very liberally furnished me a number of specimens, which he allowed to be cut for sections. Before giving the description of the form, I wish to make a few remarks upon the terminology employed in this and the succeeding paper by Mr. Barris.

Since the appearance of Prof. F. Roemer's classical work upon the Blastoidea, his terms, with slight variations, were used, both in this country and in Europe, by all the leading palæontologists. Roemer's terms are no doubt appropriate, but they have the great disadvantage of giving new names to certain parts which in allied groups had previously received a proper designation. All parts that are founded upon identity of plan, or which are analogous in their functions, should always be called by the same name. Special terms, unnecessarily introduced, lead to the impression that the differences among the groups are greater than they really are, and they form a serious obstacle to an easy perusal of the works of different writers.

Messrs. Etheridge and Carpenter have lately published through the Ann. and Mag. Nat. Hist., April, 1882, an interesting paper, "On certain points in the Morphology of the Blastoidea, with descriptions of some new Genera and Species," in which they explain the terms which they propose to use in their writings. Their terms are in conformity with those now in use for the Crinoids and other Echinoderms, and it would be of great advantage to science if they were universally adopted by future writers upon Blastoids. In order to give this terminology a wider circulation, and for the better comprehension of the succeeding descriptions, I give here an abstract of their principal terms.

The "*calyx,*" according to Etheridge and Carpenter, is composed of the "*basals*" the "*radials*" or forked pieces, and the "*orals*" or deltoid pieces. The suture between basals and radials is the "*basiradial suture*;" the more or less strongly marked ridge at the median line of each oral is the "*oral ridge.*" In the forked-shaped radials, the handle of the fork is the "*body*" of the radial, the two prongs are the "*limbs*;" between the limbs is the "*radial sinus,*" which is occupied by the "*ambulacrum.*" Of the ambulacral structures, which together fill up the radial sinus to a greater or less extent, the most important is the "*lancet-piece,*" which is excavated lengthwise by the "*food-groove or ambulacrum proper.*" Upon or against it rest the "*side-plates,*" pore-pieces of Roemer; they are marked by minute pits, the "*pinnule pits or sockets,*" which must not be confounded with the marginal pores or "*hydrospire-pores.*" The supplementary pore-pieces of Roemer are the "*outer side plates.*" Beneath the ambulacral fields are the "*interradial systems of lamellar tubes or hydrospires.*" The openings of these tubes, if directly on the ventral surface of the calyx as in *Codaster*, are called the "*hydrospire-slits*;" if they are concentrated beneath the ambulacra as in *Orophocrinus*,* the gap between the edge of the lancet-plate and the sides of the radial sinus is the "*hydrospire cleft.*" This leads downward into the "*hydrospire canal.*" The canals open externally by the "*spiracles,*" formerly called ovarian openings. The spiracle or spiracles of the anal interradius may be confluent with the anal opening to form the "*anal spiracle.*" The plates covering the mouth and peristome, and which are sometimes continued down the ambulacra covering the food grooves, are the "*summit plates or the vault.*"

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*MEEK and WORTHEN in defining, in 1869, (Geol. Rep. Ill., Vol. V, p. 464) the genus *Codonites*, were evidently not aware that Von Seebach had proposed, in 1864, (Nachr. K. Gesellsch. zu Goettingen, p. 110) for *Pentremites stelliformis* Owen and Shum. the genus *Orophocrinus*. The latter has since been adopted by Ludwig, Zittel and by Etheridge and Carpenter.

They further use the term "*oro-anal side*" for the upper truncate regions of the body, and they include herein the ambulacra.

It has been asserted by Mr. Lyon (Owen's Kentucky Rep. Vol. III, p. 468), that in the genera *Codaster* and *Pentremites* the plates, generally known as basals, consisted of two successive series of pieces, and upon this ground he proposed a new formula for the two genera. Only to the "lower series" of plates he applied the term basals, the "upper series" he called first radials. He explains the deficiency from five to three in the number of the latter plates, and the irregularity which he found in their form and position, compared with other radials, that the two equal hexagonal pieces were perfect plates, and the third smaller pentagonal one, imperfect. According to his theory, there were no first radials in two of the rays, and the rays commenced with a second radial. This curious interpretation of the plates, as might be expected, found no followers, but his view that in some of the Blastoids the plates formerly called basals were composed of two series of three pieces each, was afterwards accepted by Billings (Amer. Journ. Sci. and Arts, July, 1869), and also by Meek and Worthen (Geol. Rep. Ill., Vol. V, p. 464). The former regarded the "lower pieces" as basals, the "upper ones" as subradials; while Meek and Worthen in redescribing *Orophocrinus* (*Codonites*) *stelliformis*, O. and Shum., distinguished the two series as basals and supplementary basals, the latter to be applied to the "lower series." They objected to the name subradials from the fact that the plates do not alternate with each other. In the course of their remarks they made the peculiar statement, that the lower series or supplementary basals "*were in adult specimens of Codonites stelliformis as solid as we find them in Pentremites, young individuals, however, show clearly that they are actually composed of five or six of the upper joints of the column, enlarged and anchylosed together.*" Meek and Worthen undertook to prove this by a moderately small specimen, in which five or six joints of the column were preserved, and in the same direction divided longitudinally into three sections. It should be stated that the specimen, which was formerly in my collection—now in the Museum of Comparative Zoology at Cambridge—is not much below medium size, and, therefore, can not by any means be called a very young specimen. The column, as far as preserved, consists as in most Blastoids of remarkably short joints with sharp edges, and the joints are separated by rather deep notches; the longitudinal sutures are not shown distinctly, but probably do exist in the specimen.

If it were true, as Meek and Worthen asserted, that in "*Codonites*" the five or six upper joints became anchylosed in more adult specimens, and were transformed into solid plates, it is very singular that no transition forms have ever been found in this or any other allied species. I think a metamorphosis like this would have undoubtedly left traces of the columnar joints in the growing animal, especially since the modification, as we may safely suggest, must have taken place gradually, and joint by joint; but although I have examined more than fifty specimens of this species, I could not find the remotest traces of former stem joints, or of a suture; all that I have been able to discover is a slight angular depression around the lower end of the cup. This depression, which has somewhat the appearance of a suture, is caused simply by the more rapid spreading of the upper portions of the basals. Such at least is the case in some species of *Codonites*, *Codaster* and *Troostocrinus*, in which the base appears as if it might be bicyclic, but actually is monocyclic, and in which the lower part is almost cylindrical, and resembles an elongate columnar joint, while the upper part is conical.

It seems to me that this upward spreading of the basals can be naturally explained by the growth of the animal. The form generally throughout the Blastoids is in a young specimen more elongate than in the adult, and after attaining a certain growth, the calyx increases in height comparatively little, while the ambulacra still grow considerably longer. This disproportion in the growth of the different parts is equalized by the increase of the body in width, by which the ambulacra attain a greater curvature, pushing the basals and partly the radials, from a fairly sloping position to a more horizontal one, as shown in the following species, of which I have examined a large number of specimens in all stages of growth.

In the young *Orophocrinus stelliformis*, the ambulacra occupy only the upper truncate side of the body, the lower portions are turbinate with nearly straight sides; in very old specimens, however, the ambulacra curves so strongly, and reach down so deeply, that the radial lips were brought into a horizontal position, almost to the level of the basals, and the sides of the body became concave, thereby pushing the upper portions of the radials in a more outward direction.

Schizoblastus (*Granatocrinus*) *melo* O. & Shum. is, in its younger stages, elongate-ovate, in medium sized specimens subglobose to globose, and in large specimens depressed globose. The same modifications, but perhaps not quite so marked, take place in *Granatocrinus Norwoodi* O. & Shum., and in *Schizoblastus* (*Granatocrinus*) *Sayi* Shum.

Pentremites Godoni De Frame, in its earlier stages, is pyriform, and resembles *P. pyriformis* Say, later on it is globose. The lower portions, from the basals to the radial lips, are broadly turbinate and decidedly longer than the summit portions. Afterwards they become almost horizontal, and occupy, in large specimens, more than three-fourths the height of the body, at a time when the ambulacra, which at first were scarcely longer than wide, attain a length of more than three times their greatest width.

The modifications which here take place in the basals and radials are mainly produced by the increase in the length of the ambulacra. These plates, and particularly the basals, had acquired already at an early age a comparatively large size; later on the body of the radials increased much less in length than in width, as shown by the lines of growth, which are sometimes exposed. The basals, however, which had attained almost their full height, and now had to accommodate themselves to the increasing width of the radials, bend outward, producing thereby the angularity at the outer side of the radial cup, by leaving the lower thickened portions, which were less pliable, in their former position. This explains fully the case as we find it in *Codonites*, *Codaster*, etc., in *Pentremites*, however, under similar conditions additional modifications have taken place.

Restricting the genus *Pentremites* to species with large petaloid ambulacra, most of them have at the lower end, at the junction with the column, a little projection in form of a cone, which is almost as prominent in small specimens as in the larger ones. This cone constitutes the lower part of what appears to be a tri-partite plate, in form of a clover leaf, occupying the central portion of the basal disc, into which it extends for some distance, following its curvature. It is frequently somewhat elevated above the general surface of the basals, and can be observed in most specimens with the naked eye. The sutures which separate the basals by their shorter sides in the usual way, divide the lower leaves lengthwise. From external appearance, one feels very much inclined to take the inner part of the basals to be an independent series of plates, but on grinding the surface there is no intermediate suture. In one of my specimens, which I take to be an extremely large specimen of *Pentremites Godoni,* I find within the clover-leaf another leaf-like structure, but of less width. and beneath it eight joints of the column, divided longitudinally in the same direction as the basals. The inner leaf is at its border as distinctly marked as the outer one; it extends not far beyond the column, but is considerably wider, and very much higher than the stem joints, which are so extremely short that there are eight joints to a length of half a line. The structure is such that there can be but little doubt that the inner leaf, although differing considerably in its dimensions from the succeeding stem-joints, is actually nothing else but the proximal joint, which had become enlarged and gradually anchylosed with the basals. It is quite evident that the outer clover-leaf had a similar origin. At the outer leaf the sides of the anchylosed joint were more extended, and became almost entirely absorbed into the basal plates, leaving only external marks, while at the inner ones the column structure can yet be recognized, although the joint has here actually become a part of the basal plates. This is the only specimen in which I have observed a second series of plate-like marks, and I do not know whether this instance represents an abnormal case or is owing to the extreme size of the specimen; at any rate it gives an explanation how similar marks were produced.

In corroboration of these views I will further direct attention to *Pentremites abbreviatus*, Hambach, a very depressed species, in which the basals, even in young specimens, have an almost horizontal position, and in which as might be expected, there is no conical projection at the end of the basals. In this specimen, the leaf-like marks are very large and conspicuous, they form a somewhat triangular, clover-leaf shaped disc, with rounded extremities directed to the basal sutures. The sutures are always slightly depressed, and the parts covering these depressions, stand out so prominent, that it appears almost as if in this case, exceptionally, the anchylosis had not been completed, and in fact I found two specimens in which the upper structure apparently had partly fallen out, leaving in its place, at the surface of the basal plates, a clover-leaf-like impression. The place to which the column was attached is generally well marked, and in one specimen I found remains of the proximal segment which is exceedingly thin and delicate, and like the anchylosed joint triangular in form, but the points of the angles directed toward the sides of the upper one.

I think this fully sufficient to prove that the so-called supplementary basals in *Pentremites* consist of a columnar joint, anchylosed with the basals and more or less completely absorbed into the plate, and that the basals in the Blastoids generally were monocyclic and not bicyclic. This seems to be also the opinion of Etheridge and Carpenter, although they state distinctly that they wish to leave the question for further consideration.

HETEROSCHISMA, Wachsmuth, Nov. gen.

The form under consideration is closely allied to *Codaster*, and approaches *Phænoschisma*, Ether. and Carp. The latter, according to Etheridge and Carpenter, differs from *Codaster* in the following points: "In the partial exposure of the hydrospire slits, and in their presence in the anal interradius, as well as in the four others. *Phænoschisma* in consequence possesses ten groups of hydrospires, whilst *Codaster* has only eight. Further the former genus has relatively smaller orals than the latter, and it may possess outer side-plates to the ambulacra." (Ann. and Mag. Nat. Hist., April, 1882, p. 227.)

Heteroschisma stands intermediate between the two forms, it agrees in the above characters with *Phænoschisma* except that it has but eight groups of hydrospires in place of ten.

Admitting that the difference in the number of hydrospiral groups alone is sufficient for a separation from *Codaster*, the intermediate form must be placed either together with that genus, or be arranged under a new name. I follow the latter course, as I consider the structural differences in the oral plates as important as the numerical difference in the hydrospires, the more as they involve other important structural complications. In the typical form of *Codaster*, including the more flat-topped species with small orals, the latter plates cover almost the whole of the truncate upper face of the body, resting with their lateral sides against the inflected upper part of the limbs. The oral ridges consist of more or less strongly marked edges or elevated ridges, which occupy nearly the full width of the body. To both sides of the ridges are placed the hydrospires, all located within the limits of the oral plates, only small portions of them being continued along the sides of the limbs. In the more clavate form with small orals, for which I propose the name *Heteroschisma*, the orals are partly only exposed to view; the visible part occupies a small space around the mouth; the concealed portions, which underneath give origin to the two inner hydrospires, are overlapped by the ends of two contiguous limbs.

There is in *Heteroschisma* in the proper sense of the word, exteriorly no oral ridge; the part representing it, is concealed from view by the overlapping limbs. The limbs are formed interradially into high pyramids with steep sides, of which two of the lateral-walls form the sides of the radial sinus. The pyramids enclose all but the two inner hydrospires, and are, with the exception of these, exposed along the sides of the sinus, but neither their slits nor their folds connect externally with the oral plates. The pyramids produce also important modifications in the form and position of the hydrospires; in *Codaster* these organs enter the body nearly at right-angles, and the walls are placed almost parallel to each other; in *Heteroschisma* the hydrospires stand obliquely to the sides of the sinus, and are much wider at the outer side than at the inner. Contrary to the adjoining folds which connect with the slits, these increase in width at the inner end. The hydrospires of *Heteroschisma* are arranged closely around the mouth, while those of *Codaster* are placed away from the mouth. The differences between these two genera and the allied *Phænoschisma* are well seen in the accompanying table:

	HYDROSPIRES.		AMBULACRA.		ORALS.		ORAL-RIDGE.	
GENERA.	Eight groups.	Ten groups..	Side - plates meet sides of sinus....	Side - plates do not meet sides of sinus......	Large........	Small........	Expos'd upon the surface.	Concealed by the overlapping limbs
Codaster............................	*	....	....	*	*	....	*	....
Heteroschisma	*	....	*	....	....	*	....	*
Phænoschisma	....	*	*	....	....	*	....	*

Heteroschisma includes the following species: *Heteroschisma gracile*, the type of the genus; *Heteroschisma alternatum*, and *H. alternatum*, var. *elongatum*, Wachsmuth,[1] all from the lower part of the Hamilton group, Devonian.

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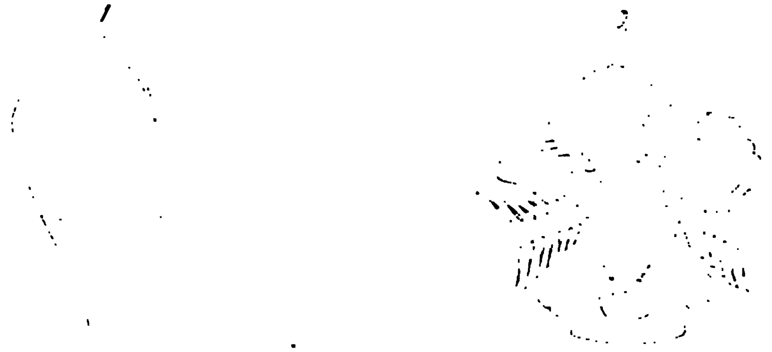
[1] Dr. Knapp, of Louisville, Ky., had the kindness to send me for examination and study, his large collection of Louisville Codasters, consisting of nearly 40 specimens in all stages of growth, and embracing at least two well-marked species. Lyon, in describing his *Codaster alternatus* (Owen's Geol. Rep. Vol. III., p. 95, evidently took all Louisville Blastoids containing hydrospire slits to belong to only one species, and this makes it difficult to ascertain now to which of the two forms the name should be applied. His generic figure, on Pl. V., Fig. 3, represents undoubtedly the form which afterwards was described by Shumard as *Codaster pyramidatus* (Acad. Sci., St. Louis, Vol. I., No. 2, Lyon's figure 3 *b* gives a small specimen of the same species; his figure 3 *a*, however, is not only an entirely different species, but a *Heteroschisma*. It might appear that the form represented by the first figure should receive Lyon's name, but this would do injustice to Shumard, the more as Lyon's descriptions are fitted for neither the one form nor the other. It must be further considered that the latter form, which like *Heteroschisma gracile*, has small orals overlapped by the limbs, and large pyramids between the ambu-

HETEROSCHISMA GRACILE, Wachsmuth, Nov. Sp.



Heteroschisma gracile, WACHSMUTH.

Fig. 1, side view of a specimen. Fig. 2, horizontal section of the hydrospires. The first figure enlarged three diameters, the other five.

Body subclavate or irregularly pyriform, pointed at the base, deeply excavated in the direction of the rays. From the foot of the basals to the radial sinus the form is elongate-obconical, the sides at the outer surface being straight or nearly so. The radials are arched, with an angularity along the median line, which culminates in the lips, but almost disappears on approaching the basi-radial suture. Intermediate between the ambulacra there are five pyramids, formed by the junction of the adjacent limbs of two contiguous radials, without the assistance of oral plates. Four of them are sharply pointed, projecting conspicuously above the level of the summit; the fifth, the one containing the anal orifice, is a little lower and truncate. Ambulacra, placed at the bottom of a deep sinus; curving gently in an upward direction. The greatest width

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lacra, is readily separated again into two sections, the one larger, more elongate, and decidedly clavate, with nearly straight sides; the other smaller, with convex sides, and somewhat larger and more prominent oral plates. Under these circumstances I would be probably justified to drop Lyon's name entirely, but not wishing to overburden the literature unnecessarily with names, I propose to apply his specific name to the smaller form, as this is probably represented by Fig. 3 *a*, and which will be known as *Heteroschisma alternatum*. The larger type, which possibly may represent a more adult form of the other, but more probably is a good variety or even an entirely distinct species, can be distinguished as *Heteroschisma alternatum* var. *elongatum*, which may be changed into *H. elongatum* should the above characters be considered sufficient for specific distinction. Shumard's species is easily recognized by being much more flat-topped, that it has large orals, and these abutting against the deflected upper ends of the limbs, and that the radials generally possess along the lateral sutures, near the margin, one or more rather deep, longitudinal grooves. Lyon, in asserting that the hydrospiral grooves were "probably capable of being compressed or impressed," made the mistake of taking specimens of *Codaster pyramidatus* as the compressed, and those of *Heteroschisma alternatum* as the impressed condition of his species. It should be further remarked that none of the Louisville specimens, upon which Lyon based his bicyclic base in *Codaster*, show any such structure.

of the body is across the lips, where the section is strictly pentagonal, while across the basals it is obscurely triangular. Average length and width, as taken from eleven specimens, as eight to five, actual length from three to six-tenths of an inch. The surface of the test is perfectly smooth, without ornamentation.

Basals long, in form of an elongate cup; column-like, extended at the lower end; upper face somewhat excavated for the reception of the radials, with an obtuse angle beneath their juncture.

Radials moderately increasing in width to the sinus. The length of the radial body equal to or surpassing its greatest length, and equal to the length of the basals. The limbs occupy less than one-third the entire length of the plate, they are slightly bent inward, those of two contiguous radials forming a triangle, of which the horizontal side (between the lips of the adjoining radials), is but little longer than the two lateral sides. At the anal interadius, the upper angle is truncated by the anal aperture, and the outer side of the pyramid is more sloping. Sinus short, and remarkably deep.

The oral plates are small, and are only partly exposed to view, one half or more of each one being hidden beneath the radials. The exposed part, which consists of barely more than what might be called the lips of the mouth, is slightly projecting along the margin; it is in form rhomboidal, but the angle toward the radials is covered by the tips of the overlapping limbs. The concealed portions are at the four lateral interradii placed beneath the large pyramids which have been described; they are longer than wide, and their distal end is somewhat extended outward and downward. The median portion of the plate is provided longitudinally with a canal, which from its position may have connected the hydropires with the outer vascular ring. The description of the oral plates is made principally from a specimen, in which the greatest part of the radial limbs had weathered away, thereby exposing the parts below. As seen in this specimen, the lateral sides of the concealed oral plates give off the two inner hydrospires for each group, the first of which, at several places, is preserved to its full length; the second, however, is recognized only by a stump, and there is a notch for the intermediate slit. The oral plate of the anal interradius is constructed near the mouth somewhat different from the orals of the four regular sides; the parts which there are covered by the limbs, and form the oral ridges, take here a more inward direction, and compose the sides and inner floor of a little cavity, which forms the entrance to the anal aperture. The opening into this cavity is large, somewhat broadly subtriangular, and there is a passage in a downward course, which enters the inner body at the end of the oral plate.

The ambulacra are almost linear, rounded at the distal end: they rest deeply between the steep sides, the side-plates meeting the sides of the sinus but are rarely touching them. The ambulacra connect with the body through the lower side of the lancet-piece, close to its middle line. The surface of the ambulacra is divided by the food groove only, there being no other indented lines toward the sides, such as seen in the Louisville species. The lancet piece is entirely covered by the side pieces, it is lanceolate, and rests with its proximal end, which is angular, between—and partly upon—adjoining oral plates. The number of side pieces varies from 16 to each side in the smallest specimens to 22 or 23 in the largest ones, each one with a socket, probably for the reception of a pinnule. There are also outer-side pieces but no hydrospire pores. The oral aperture is pentagonal and comparatively large.

The hydrospires are arranged in eight groups, of from 8 to 9 to each set, and there are as many slits along the sloping sides of the radial sinus. The two inner slits which are longer than any of the rest, are concealed from view by the overhanging sides of the lancet-piece. The succeeding ones are visible externally and decrease in length with the decreasing width of the sides of the sinus. Not all, however, decrease in that proportion, this is only the case with the four or five outer ones, of which the outermost is but little longer than wide; the preceding three, from the fourth inward, are nearly of equal length. It should also be remarked that the slits have an irregular outline even in the best preserved specimens, and it appears as if there had been pores in place of the slits. Each slit opens into a sac. This, however, is so narrow, that the walls almost touch each other, except at the lower end, where it attains almost the width of the alternating folds of the hydrospires. There is a great difference in the depth of the sacs; the two inner ones extend into the body for a comparatively short distance, all succeeding ones increase their depth in the same proportion as they grow shorter upon the surface of the body.

Remarks: *Heteroschisma gracile* is in its form and general habits almost identical with *Phænoschisma Verneuilli* Eth. and Carp, but it has eight groups of hydrospires and not ten. It differs from both

Heteroschisma alternatum and *H. elongatum*, but the summit of the pyramids extends considerably above the crests of the oral plates, while in the two others the summit scarcely reaches the level of the peristome; it also has narrower, almost linear ambulacra, against slightly petaloid ones in the others, and these are divided by the food groove only, while the Louisville species have three indented lines along their surface. It further differs from *H. alternatum* in having straight, and not convex sides along the calyx, and a conical, more sharply pointed basal cup.

It is barely possible that *Pentremites subtruncatus*, Hall (Geol. Rep. Iowa, Vol. I, Pt. II, p. 485), is identical with this species. A comparison is impossible as Hall's description is so indistinct, that not even the genus can be identified. He refers it to forms like *Pentremites Rheinwardti*, and mentions "ovarian openings," which if present suggest a very different thing. Should, however, hereafter, the identity be proved, the name must be placed as a synonym under *Heteroschisma gracile*.

Position and locality, etc.: Found near the top of the Hamilton group, Alpena, Mich.

(The type specimens are in the collections of Prof. Barris, and Charles Wachsmuth.)

Description of some new Blastoids from the Hamilton Group, by W. H. BARRIS.

ELÆACRINUS, Roemer.[*]

SYN.—Pentremites Troost, 1841, 6th Rep. Geol. Tennessee,
Nucleocrinus Conrad, 1843, Jour. Acad. Nat. Sci. Phila. Vol. VIII, p. 280.
Olivanites Troost, 1850, Cat. name.
Elæacrinus Roemer, 1851, Monog. Blastoidea, p. 55.
Olivanites Lyon, 1857, Geol. Sur. Kent, Vol. III, p. 490.
Nucleocrinus Lyon and Cass, 1859; Hall, 1862; Shumard, 1862.
Elæacrinus Shumard, 1866, Trans. St. L. Acad. Sci., p. 368.
Nucleocrinus, Canadensis? Montgomery, 1881; Can. Nat. Vol. X, No. 2.

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[*] At the suggestion of Mr. Charles Wachsmuth, and in conformity with the views of the late Dr. Shumard (Cat. Palaeoz. Foss., in the Trans. St. L. Acad. Sci., 1866, p. 368), I give Roemer's later name *Elæacrinus* preference over *Nucleocrinus*, Conrad. Conrad's entire description is as follows: "*Nucleocrinus* Conrad. The genus differs from *Pentremites*, Say, in having only one perforation, which is central. "In this description, the only distinguishing character is erroneous, the accompanying figure poor and incorrect, and Hall's excellent descriptions of *Nucleocrinus* were published ten years later than those of Elæacrinus. Roemer, in proposing the latter name, gave a good definition of the genus. He found the central aperture which Conrad had pronounced "the only perforation at the top," closed in perfect specimens, and surrounding it he discovered one large and ten smaller openings.

ELÆACRINUS OBOVATUS, Barris., Nov. Sp.

Fig. 3, cross section of the hydrospires of *Elæacrinus obovatus*, Barris. Enlarged two diameters.

Body obovate or elongate-baloon shaped, more than once and a half as long as wide: upper half wider than the lower, semiovoid: greatest width at about two-thirds from the base; lower half gradually increasing in width to the distal end of the ambulacra: base truncate with a deep concavity which is filled by the column. Cross section pentangular, with straight or very slightly convex sides, except along the basals, where the sides are somewhat concave, and the section more stellate.

Basals deeply imbedded within the columnar cavity, the outer angles barely reaching the margin. Radials comparatively small; length twice their width at the basi-radial suture, gradually increasing upward, so that the forks or limbs at their upper side are about equal in width to the body of the plate at its lower side. The lateral sides are somewhat thickened at the upper face of the edge, more particularly toward the lower end of the plate, where they produce indistinct ridges at the suture lines. The upper side of the limbs is gracefully curved in an upward direction, with re-entering angles toward the lateral sutures, and deeper ones toward the radial sinuses. From the bottom of the plate there extends to the radial sinus (which in this species is about half way to the top of the limbs), a conspicuous rounded ridge, ending in a very prominent lip, and it is this structure mainly which produces the truncation toward the basal region, which otherwise would not be very perceptible.

Oral or deltoid pieces large, measuring almost four-fifths the length of the body; broad lanceolate. The four regular orals have a length equal to twice their greatest width. The fifth, that of the posterior side, which in this genus is divided throughout its full length by a large anal plate, occupies, including the latter piece, no greater width than the four regular orals, and the two halves are narrower at any place than the interposed anal plate. The latter is lanceolate, of nearly equal width throughout, slightly tapering at the upper end. Its lower side rests on the same surface with the other plate, but gradually rises above the general level and at the top is highly elevated, standing out conspicuously over the adjoining parts. Even in height it extends beyond the limits of the other parts of the body.

Anal aperture large, oval in form, horizontal in position. Toward the outer side the opening is formed by the wall of the anal plate, which at the upper end is bulging outward without being excavated. The lateral sides of the aperture are formed by the upper curved ends of the oral side-plates, which are connected by two or three small anal vault pieces, and these constitute the upper boundary of the aperture.

Ambulacra long, narrow, linear, raised above the general level of the body, except close to the oral pole, near which they curve abruptly toward the oral opening, and the ambulacrum becomes located below the abutting surface. The lancet-piece is deeply grooved along the median line, and when the side-pieces (pore-pieces of Roemer) are not in place, there is at the suture, along each side of the plate, a deep sulcus, penetrated by the hydrospire-pores. This sulcus, however, when the side-pieces are *in situ* is totally filled, and the sides of the ambulacrum rise abruptly above the abutting edges. The side-pieces rest against the upper face of the deeply crenulated ridges of the lancet-piece. They are strongly wedge-shaped and placed obliquely to the ambulacral or food-groove, with the smaller angle directed to the ab-oral side. Their number is from about sixty to nearly ninety in very large specimens. The outer side-pieces (supplementary pore-pieces of Roemer) are comparatively large, their longer side being about two-thirds, their shorter sides fully one-half of the corresponding sides in the pore-pieces.

The summit is a flat disc, somewhat depressed in the middle, sub-pentangular in outline, the angles resting against the slightly truncated upper part of the oral plates, leaving in the direction of each ambulacrum a good sized passage. The central aperture is pentangular, rather deeply depressed.

Spiracles ten, one to each side of the ambulacrum, those of the posterior side not in contact with the anal aperture. They are in this species not easily detected, being placed laterally within the projecting edges of the orals, which for their reception are at this place more prominent, and somewhat excavated. The hydrospires are arranged in ten groups, with two in each group; they are in form similar to those of *Granatocrinus Norwoodi*, but comparatively a little larger. Hydrospire-pores small, and more or less hidden.

Column of medium size, round, composed at the upper end of high joints.

The ornamentation of the radials consists of indistinct concentric curves sub-parallel with the arched upper surface of the plate. The ornamentation of the oral plates, as in most species of *Elæacrinus*, is sharply divided by two longitudinal lines, the median part (which in position and somewhat in form, at the four lateral sides of the body, corresponds to the large anal plate of the posterior side) is more or less destitute of ornament. The two sides, however, are crowded with rows of small granules, arranged so as to divide the field into narrow parallel spaces, which are transversely arranged, and of the width of the pore-pieces.

Observations.—Elæacrinus obovatus differs from *Elæacrinus* (*Nucleocrinus*) *angularis*, Lyon, in the greater length of the body, and in having straight and not concave sides. It resembles, perhaps, closest *Elæacrinus* (*Nucleocrinus*) *lucina* Hall, and may be identical with the larger form noticed in the same paper, and which Hall considered a variety or more adult phase of the above species. Hall describes the latter as more expanded in the upper part of the body, with the base proportionally narrower, and this agrees with our species; but the body is comparatively longer than in Hall's smaller type; while it should, if representing the adult form of the other, (according to Wachsmuth; see the preceding paper), on the contrary be wider and not higher. In *Elæacrinus lucina* the basals are almost on a plane with the radials, and the ambulacra touch the bottom, which is not the case in *E. obovatus*; in the former the lower truncate portions are much wider, and the basals instead of being deeply concave, are provided with an elongate node in the center.

The above description was made from ten specimens of all sizes, the largest one measuring one inch and three quarters in length, the smallest seven eighths of an inch.

Geological position, etc.: Found in the shales of the Hamilton group at Buffalo, in limestone of the same age at Iowa City, and at the top of the Hamilton group in the Thunder Bay region of Northern Michigan.

The original specimens are in the collection of Mr. Charles Wachsmuth and in my own.

ELÆACRINUS MELONIFORMIS, Barris, Nov. sp.

Body small, ovoid, height nearly one-half more than the width; greatest width through the median part, or a little above; curvature toward the two poles nearly equal, but the pole itself at the abactinal side abruptly depressed, and the concavity perfectly filled by the column. Surface of the ambulacra raised but little above the general plane of the body. The plates along the sides of the ambulacra are marked with obscure transverse grooves, bordered at each side by a sharp ridge, which forms along the median portions of the plate a deltoid-like figure. The ridges which join with one end at the summit, with the other at the radial lips, form together around the body a well marked penta-petaloid figure in which the ambulacra are placed along the median line; and as the ridges in this species happen to be more conspicuous than the margins of the ambulacra, the ridges appear as the boundaries of the latter. Cross-section along the upper half of the body obscurely decagonal, almost circular, decidedly pentagonal across the lips of the radials.

Basals small, entirely hidden within the columnar cavity.

Radials small, body part longer than usual in this genus, their lower portions resting within the concavity, whence they bend abruptly in an opposite direction, forming a sharp edge at the end of the body. Length more than twice the width at the basi-radial suture, which is about equal to the width of a limb at its upper side. Sinus very short enclosing but little more than the lip, which is strongly protruding, and from which a very prominent rounded ridge proceeds to the lower edge of the plate. The upper sides of the limbs are convex, with a re-entering angle above the lateral sutures.

Oral plates large, occupying four-fifths of the length of the entire body, divided by two raised lines into three parts, the inner or deltoid part provided with fine granules, the outer part with transverse grooves, which are equal to the number of side plates in the ambulacra. The anal plate which divides the oral piece of the posterior interradius, differs in form but little from the deltoid-shaped portions of the other four interradial sides; it is however a little wider, and at the upper end protruding outward. The anal-aperture is large, rhomboidal, the opening in an upward direction. It is bordered towards the peristome by two summit plates which rest against the upper ends of the two sections of the oral plate.

Ambulacra linear, comparatively shorter and probably wider than in any other species of *Elæacrinus;* lancet-piece exposed within the food groove, but only at the upper end of the plate, its lower half is perfectly covered by the side-plates. There are 36 to 38 side pieces, (outer side pieces cannot be distinguished in the specimens) with a deep socket to each plate. The hydrospire-pores are only seen when the side plates are broken away.

Spiracles ten, one to each side of the ambulacrum; slit-shaped, placed like those of the preceding species within the projecting lateral edges of the orals; those of the anal side non-confluent with the anal aperture. The hydrospires are unknown.

The summit (which in both type specimens has been preserved) is composed of but few comparatively thick pieces which are similarly arranged as in *Elæacrinus oboratus.* Column round, central perforation very small.

Observations: This species has its closest affinity with *Elæacrinus* (*Nucleocrinus*) *elegans* Conrad, from which it differs in the more elongate form, in the mode of ornamentation, in having almost straight in place of concave interradial sides, and in the less protruding and comparatively shorter ambulacra. The latter, in Conrad's species, reach to the truncate portion of the body, while in *E. meloniformis* they occupy only five-sixths of that length. It differs from *E. Verneuilli* in being a much smaller species, and in the entirely different ornamentation; from *Elæacrinus angularis* Lyon, *E. lucina* Hall and our *E. oboratus* as lacking that marked angularity of the body so conspicuous in each of these species. There is a general resemblance to the figure given by Montgomery of *Nucleocrinus Canadensis* but no direct comparison can be made as his paper deals in generic rather than specific descriptions. The only specific characteristic clearly brought out, "the prominently arched radials" are totally inapplicable to our species.

Geological position, etc.: In the shales of the Hamilton Group, Buffalo, Iowa, and at the top of the same group in the Thunder Bay region of Northern Michigan.

PENTREMITIDEA*, D'Orbigny.

1849. D'Orbigny, Prodrome de Palæont, p. 102.
1853. D'Orbigny, Cours Elementaire, p. 139.
1882. Etheridge and Carp., Ann. and Mag. Nat. Hist., p. 220.

PENTREMITIDEA AMERICANA, Barris, Nov. Sp.

Body small pyriform, height twice the greatest width, which is across the radial lips. Ab-oral side in form of a cone with slightly convex sides, triangular at the end, but gradually assuming a strongly marked pentalobate aspect, actinal side of the body equal in length to the ab-actinal side; curving gently in an upward direction; broadly truncate and somewhat depressed at the oro-anal regions.

Basals forming a triangular vase, with rounded angles, and of a height greater than the width at the top, upper edges slightly concave.

Radials two-thirds the length of the body, a little more sloping than the basals; width at basi-radial suture equal to the width of the plates at the opposite side. The forks 'occupy two-thirds the length of the plates, are comparatively narrow, and end in a sharp point which constitutes the uppermost part of the entire body. The sides toward the sinus are elevated and formed into sharp edges which stand out at right angles above the ambulacra. Radial lips prominent.

The oral plates are not observed in a side view, they are extremely small, and are placed against the tips of two adjoining limbs, within the truncation of the peristome, where they form a narrow rim around the spiracles.

Ambulacra broadly linear, the lateral sides depressed, and forming a deep sulcus; the inner portions almost on a level with the forked plates, except near the mouth, where the whole ambulacrum lies deeper than the surrounding plates.

Spiracles ovate, drawn out in a sharp angle, pointing to and situate close to, the mouth. They are placed within the oral plates, taking up almost their whole surface, leaving exposed a very narrow

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*The genus *Pentremitidea* differs from *Troostocrinus*, Shumard, its nearest allied form, in having quite inconspicuous oral plates, always placed within the truncate upper face of the body, and only five spiracles; which are strictly interradial; while in *Troostocrinus* the orals are always visible in a side view of the specimen, and there are ten slit-like spiracles along the lateral edge of the ambulacra, and a separate anal opening. I am indebted to Mr. Wachsmuth for the recognition of the above species as Pentremitidea, and who claims that it is the first one that has been discovered in America.

rim; four of them are equal, the posterior one is larger, and confluent with the anal aperture. Hydrospires and summit plates unknown.

The ornamentation consists in fine concentric lines following the general contour of the plates.

Of the two specimens from which this species is described, one is nearly perfect and larger than the other. On one side of the smaller one is a crushed mass of slender arms, composed of pieces of about equal width and height, which possibly may be some of the pinnules.

Pentremitidea Americana resembles very closely *Pentremites clavatus*, Schultze—*Pentremitidea clavata*, Eth. and Carp.; so closely, indeed, that it might almost be taken for it; the latter, however, has comparatively longer basals, is more pentalobate, has wider limbs, with decidedly convex sides in place of almost straight ones, and the ambulacra extend beyond the general surface.

Geological position, etc.: In the upper portion of the Hamilton group in the Thunder Bay region of Northern Michigan. The types are in my own collection.

INDEX.

PAGE.
Acondylacanthus 241
'' Mudgianus 244
'' nuperus 242
'' rectus 241
'' xiphias 244
Acrocrinus 343
'' Wortheni 343
Agassizocrinus 315
'' hemisphericus 316
'' papillatus 315
Agelacrinoidea 335
Alumina 40
Allagecrinus 341
'' Carpenteri 341
Ancient soils 23
Anticlinal axis 39, 41
Archæocidaris 337
'' Edgarensis 337
'' Illinoiensis 338
'' spino-clavatus 337
Area of Coal Measures in Illinois 1
Artesian, boring
'' '' at Canton 5
'' '' at Marsailles 50
'' '' at Olney 5, 7, 40
'' '' at Streator 40, 49
Asteroidea 327
Asteroptychius 248
'' tenellus 248
Atkinson, coal in 4
Aviculopecten 321
'' Varsoviensis 321

Batacanthus 253
'' necis 253
Battery Rock coal 3
Blastoidea 346
Bloomington, coal in 4
Boring for coal
'' '' at Chapin 32
'' '' Charleston, section of 29
'' '' Danville, section of 23
'' '' Farmer City 16

PAGE.
Boring for coal at Harvel, section of 27
" " Lemonton 31
" " Litchfield Coal Co. 37
" " Marissa, section of 31
" " Marseilles, section of 50
" " Milford 25
" " Pana, section of 22
" " Peru, section of 23
" " Prairie City 25
" " Riverton 6
" " St. Johns 38
" " Streator 10, 15, 19
Breese, coal at 9
Brick, clay for 12, 25, 40
Brock's Ford, limestone at 41
Building stone 44

Camerophoria Giffordi ....
Caledonia Coal Co. shaft 16
Canton, boring at 5
Carboniferous formation, Upper Mississippi 58
Carlinville limestone 19
Cass county boring, section of 15
Cement, hydraulic 39
Centralia, coal at 6
Chaenomya 319
" Maria 319
Chester group 34
Chitonodus 109
" antiquus 116
" liratus 119
" Springeri 112
" tribulis 117
Cholaster 328
" peculiaris 329
Clay for pottery 12, 25, 40
Clay, black 14
Clay, fire 40
Coal area 1
Coal oil 37
Coal, extent of 42
Coal Measures of Illinois 1
" section of 2
" in Southern Illinois 3
Coal products 7
Coal No. 1 .... 1, 5, 12, 16
" 2 .... 4, 12, 25, 42
" 3 .... 4, 11, 42
" 4 .... 4, 25, 42
" 5 .... 4, 5, 6, 12, 15, 16, 17, 18, 25
" 6 .... 5, 12, 14, 17, 25, 35
" 7 .... 7, 13, 14, 17, 25, 43
" 8 .... 17, 19, 23

PAGE.

Coal at Breese.... 9
'' Brock's Ford.... 44
'' Centralia.... 6
'' Danville.... 7
'' Decatur.... 6
'' Fulton Co.... 6
'' Gallatin.... 7
'' Hodges' Creek.... 12
'' La Salle.... 40
'' Nashville.... 10
'' Okawville.... 11
'' Peoria.... 6
'' Roodhouse.... 3, 12
'' Saline county.... 7
'' Sandoval.... 6, 9
'' Springfield.... 6
'' Trenton.... 10
'' Troy.... 10
'' Williamson county.... 7
'' Manchester.... 11
Cochliodontidæ.... 62
Cochliodus.... 120
'' ? bialveatus.... 169
'' ? convexus.... 169
'' ? Keokuk.... 169
'' Leidyi.... 127
'' obliquus.... 126
'' Van Hornii.... 120
Compsaster.... 327
'' formosus.... 327
Conularia.... 325
'' Chesterensis.... 325
Copodus.... 227
'' Van Hornii.... 229
'' pusillus.... 231
Ctenacanthus.... 233
'' Buttersi.... 240
'' cannaliratus.... 239
'' Coxianus.... 233
'' deflexus.... 234
'' gracillimus.... 238
'' Harrisoni.... 236
'' Pellensis.... 237
Cyathocrinus.... 309
'' Marshallensis.... 310
'' parvibrachiatus.... 309
Cypricardia.... 326
'' ? Randolphensis.... 326

Danville, boring at, section of.... 24
Danville, coal at.... 7
Decatur, coal at.... 6
Deltodus.... 141
'' cinctulus.... 146
'' intermedius.... 153

PAGE.
Deltodus latior........ 145
" occidentalis?........ 150
" parvus........ 151
" Powellii........ 154
" propinquus........ 156
" trilobus........ 148
Deltodopsis........ 158
" affinis........ 160
" angustus........ 163
" convolutus........ 165
" exornatus........ 168
" inflexus........ 167
" St. Ludovici........ 161
Deltoptychius........ 89
" expansus........ 98
" nitidus........ 99
" primus........ 93
" Varsoviensis........ 96
" Wachsmuthi........ 93
Dentalium........ 325
" Illinoiensis........ 325
Devonian limestone, in Rock Island county........ 2
Diagram illustrating the stratigraphical distribution, and the relations of the genera of Cochliodonts........ 61
Dichocrinus........ 313
" Coxanus........ 313
" Hamiltonensis........ 313
Dimension stone for the monument of Governor Bond........ 35
Drain tile........ 25, 40
Drepanacanthus........ 253
" reversus........ 253

Echinodermata........ 327
Echinodiscus........ 335
" optatus........ 336
Economical Geology........ 1
Edgewood shaft, record of........ 33
Effingham county, coal in........ 33
Elaeacrinus........ 357
" angularis........ 360
" elegans........ 362
" lucina........ 360
" meloniformis........ 361
" obovatus........ 358
Eretmocrinus........ 306
" Varsoviensis........ 306
Eunemacanthus........ 246
" costatus........ 246
Eupachycrinus........ 311
" asperatus........ 311
" Monroensis........ 312
Evansville quarry........ 36

Fairview, coal in........ 4
Forest beds........ 23
Fossils in LaSalle county........ 41, 47

PAGE.
Fossil shells L. Carb. limestone.... 323
Fulton county, coal in.... 3
Fusulina limestone.... 27

Gallatin county, coal in.... 4.7

Glassware, sandstone for.... 40
Glymmatacanthus.... 249
"   petrodoides.... 249
"   rudis.... 249
Gyracanthus.... 251
"   ? cordatus.... 251
Greene county, coal in.... 3,12
"   "   section at Roodhouse.... 3
Grindstone grit.... 37

Harvel, boring at, section of.... 37
Heteroschisma.... 352
"   alternatum.... 357
"   gracile.... 354
Hybochinus.... 331
"   spectabilis.... 332
Hydraulic cement.... 39

Ichthyodorulites.... 233
Illinois Coal Fields.... 1
Invertebrates, description of.... 270
Introduction to Palaeontology.... 56
Iroquois county, boring, section of.... 25
Irving, oil wells at.... 38

Jackson county, coal in.... 4
Jersey county, coal in.... 12

Keokuk limestone.... 16
Kirkpatrick's ford, outcrop of coal.... 42

LaSalle, coal in.... 4
LaSalle county, notes on.... 39
Lecythiocrinus.... 317
"   Adamsi.... 317
Lemonton, boring at.... 31
Lepidechinidae.... 331
Lime, materials for.... 40
Litchfield, shaft at.... 28
"   coal oil in.... 37
Lower Magnesian limestone.... 39

Macoupin county, coal in.... 12
Madison county, coal in.... 10
Magnesia.... 40
Marissa, boring at.... 30
Marietta, quarry at.... 37
Marsailles, boring for water.... 50
Marshall county, shaft in.... 29
McDonough county, coal in section of.... 3,24
Montgomery county, shaft in.... 28

PAGE.
Murphysboro, coal in 4
Nashville, shaft, section of 10
Neeleyville, coal in 33

Oglesby, shaft in, section of 48
Oil wells 38
Okawville, shaft in 11
Olney, coal at 5, 7
Onychocrinus 307
" distensus 307
Ophiuroidea 330
Oracanthus 255
" rectus 257
" vetustus 255
Orthoceras 323
" Illinoienses 323
" La Sallensis 324
" Okawensis 324
Orthopleurodus 190
" carbonarius 192
" convexus 193
" Nova Mexicanus 195
Outcrop of coal 42

Palæasteridæ 327
Palæocrinoidea 270
Palæontology of Illinois 344
Pana, boring at 24
Patterson's shaft 42
Peddicord's well 50
Peoria county, coal mines in 6
Pentremites 357
" subtruncatus 357
Pentremitidea 363
" Americana 363
" clavata 364
Perischœchinidæ 331
Perischodomus 333
" Illinoiensis 333
Perry county, boring in 38
Phœnoschisma 356
" Verneuilli 356
Physonemus 252
" falcatus 252
Pinna 326
" St. Ludovici 326
Platycrinus 306
" Monroensis 306
Pleurotomaria 324
" Montezuma 324
Pnigeacanthus 259
" trigonalis 259

PAGE.
Poecilodus.......... 131
  " carbonarius.......... 139
  " Cestriensis.......... 135
  " Springeri.......... 139
  " St. Ludovici.......... 131
  " Varsoviensis.......... 131
  " Wortheni.......... 136
Poteriocrinus.......... 269
  " arachnaeformis.......... 281
  " asper.......... 278
  " asperatus.......... 280
  " briarius.......... 279
  " Burketi.......... 270
  " Claytonensis.......... 288
  " clytis.......... 294
  " Columbiensis.......... 293
  " Coxanus.......... 269
  " cultidactylus.......... 301
  " Fountainensis.......... 286
  " Hamiltonensis.......... 273
  " Illinoiensis.......... 289
  " Iowensis.......... 272
  " Kaskaskiensis.......... 300
  " latidactylus.......... 275
  " Nauvooensis.......... 282
  " occidentalis.......... 278
  " Okawensis.......... 296
  " Orestes.......... 273
  " Otterensis.......... 283
  " peculiaris.......... 298
  " penicilliformis.......... 276
  " Popensis.......... 296
  " propinquus.......... 299
  " Richfieldensis.......... 285
  " Salteri.......... 291
  " sculptus.......... 292
  " similis.......... 295
  " spinobrachiatus.......... 290
  " subramulosus.......... 284
  " Talboti.......... 287
  " tentaculatus.......... 277
  " tenuidactylus.......... 271
  " validus.......... 287
  " Varsoviensis.......... 290
  " venustus.......... 297
Prairie City, shaft, section of.......... 24
Psammodontidæ.......... 197
Psammodus.......... 197
  " angularis.......... 222
  " cælatus.......... 217
  " crassidens.......... 218
  " glyptus.......... 209
  " grandis.......... 211
  " Lovianus.......... 207

PAGE.
Psammodus plenus 213
" Springeri 202
" tumidus 205
" turgidus 206
Psephodus 62
" latus 72
" lunulatus 71
" obliquus 66
" placenta 69
" symmetricus 71

Quarry
" at Evansville 36
" Marietta 37
" Rockville 36

Rhodocrinus 305
" Coxanus 305
Richland county, coal in 5
Riverton, coal at and boring 4
Rock Island, coal in 1
Rockville, quarry at 36
Roodhouse, shaft, section of 12

Saline county, coal in 4, 7
Sandalodus 184
" elongatus 106
" parvulus 107
" planus 102
" Sp? 105
Shaft
" at Athens 14
" Auburn 14
" Caledonia Coal Co 46
" Dawson 28
" Decatur 17
" Edgewood 33
" Farmer City 16
" Gillespie 12
" Girard 13
" Greenview 14
" LaSalle 45
" Mattoon 20
" Nashville 10
" Niantic 19
" Oglesby 48
" Okawville 11
" Patterson 42
" Peru 43
" Prairie City 3, 24
" Roodhouse 12
" Sandoval 9
" Sweetwater 14
" Tallula 14
" Trenton 10
" Troy 10

PAGE.
Shaft at Winchester 11
" Winona........ 29
St. Louis beds 16
St. Peters Sandstone........ 39, 50
Streator boring for Artesian water........ 40
" coal, outcrop of........ 42
Table of Carboniferous formations, Upper Mississippi........ 58
Tæniodus 75
" fasciatus?........ 76
" obliquus........ 78
" regularis........ 77
Talarocrinus........ 314
" ovatus........ 314
Taxocrinus........ 308
" Fletcheri. 308
Tile, clay for........ 12, 25, 40, 51
Tomodus........ 171
" ? limitaris........ 173
Tremataster........ 330
" difficilis 330
Trenton limestone........ 40, 41
Trenton, shaft at........ 10
Troy........ 10
Vaticinodus........ 80
" ? carbonarius........ 88
" ? discrepans........ 83
" ? lepsis........ 88
" ? similis........ 86
" ? simplex........ 84
" ? vetustus........ 82
Vermilion county, coal in........ 7
Warsaw beds........ 16
Washington county, coal in........ 10
Water, salt 31
Wells, artesian........ 5, 7, 40, 50
" oil........ 38
" salt........ 38
Williamson county, coal in........ 7
Winona, shaft at........ 29
Xystrodus........ 175
" bellulus 183
" imitatus........ 180
" inconditus 179
" simplex........ 178
" verus........ 183
Zeacrinus........ 302
" Coxanus........ 302
" Keokuk........ 303
" Pikensis........ 304

ERRATA.

Page 11- 20th line from bottom, for "Winchester" read "Manchester."
Page 35--4th line from top, for "sandstone" read "limestone."
Page 86 -13th line from bottom, for "No. 2" read "Coal No. 2."
Page 46 -3d line from top, for "fossels" read "fossils."
Page 49—21st line from top, for "localiiy" read "locality."
Page 74—3d line from top, for "cunulatus," read "lunulatus."
Page 77—8th line from bottom, for "subhromboidal" read "subrhomboidal."
Page 80—15th line from bottom, for "anterior-lateral" read "antero-lateral."
Page 91—15th line from top, for "obliquity cuneate" read "obliquity and cuneate."
Page 108 - 10th line from top, for "situated a" read situated."
Page 120 -11th line from bottom, for "Cochiliodus" read "Cochliodus."
Page 139—14th line from bottom, for "antero-latera" read "antero-lateral."
Page 157 -Bottom line, for "porterior" read "posterior."
Page 163 -17th line from top, for "contracts" read "contrasts."
Page 187 -Top line, for "escribed" read "described."
Page 210- 2d line from top, and page 211, 10th line from top, for "crassidus" read "crassidens.
Page 240—Top line, for "costae" read "costal."
Page 254—12th line from bottom, for "tenticles' read "tentacles."
Page 255--13th line from bottom, for "snarply" read "sharply."
Page 259 -Top line of diagnosis, for "Dormel" read Dermal."
Page 285—11th line about from botton, for "annal" read "anal."
Page 299—Top line, for "sliping" read "sloping."
Page 333--In head line "Perishodomus," for "GENSS" read "GENUS."

PLATE I.

PAGE.

Fig. 1. PSEPHODUS OBLIQUUS, St. J. and W. 66

1 *a*. Large median tooth, right ramus of lower jaw, viewed from above; 1 *b*, do., from inner margin; 1 *c* do., outer margin; 1 *d* do., antero-lateral border, showing crenulated coronal fold; 1 *e* do., postero-lateral border, showing broad undulations. Kinderhook; Burlington, Iowa. Coll. Prof. Worthen.

Fig. 2 *a*, *b*, *c*, *d*, *e*, similar views of a large median tooth, referred to the right ramus of upper jaw. Same formation, locality and collection.

Fig. 3 *a*, *b*, *c*, *d*, *e*. Same views of tooth, left ramus of upper jaw. Same formation, locality and collection.

Fig. 4 *a*, *b*, *c*, *d*. Similar views of an elongate, more convex tooth, identified with the preceding form. Kinderhook upper fish beds; Burlington, Iowa. Coll. Mr. Wachsmuth.

Fig. 5 *a*, *b*, *c*, *d*, *e*. Similar views of a very small, longitudinally abbreviated tooth, referred to the same position upon the jaw as the last, with which it is provisionally identified. Same formation, locality and collection.

Fig. 6. PSEPHODUS ? SYMMETRICUS, St. J. and W. 71

6 *a*. Mandibular tooth, right ramus, seen from above; 6 *b* do., outline from inner margin; 6 *c* do., outer margin: 6 *d* do., profile outline from antero-lateral border, foreshortened. Kinderhook lower fish-bed: Burlington, Iowa. Coll. Mr. Wachsmuth.

Fig. 7 *a*. A very small, nearly entire tooth of the left ramus of lower jaw, provisionally identified with the last, view from above, enlarged; 7 *b* do., inner margin; 7 *c* do., showing outer inrolled margin; 7 *d* do., profile from antero-lateral border. Kinderhook, upper fish-bed; Burlington, Iowa. Coll. Mr. Wachsmuth.

Vol. VI PL. I

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (Lower Carb.) PSEPHODI.

Kinderhook.

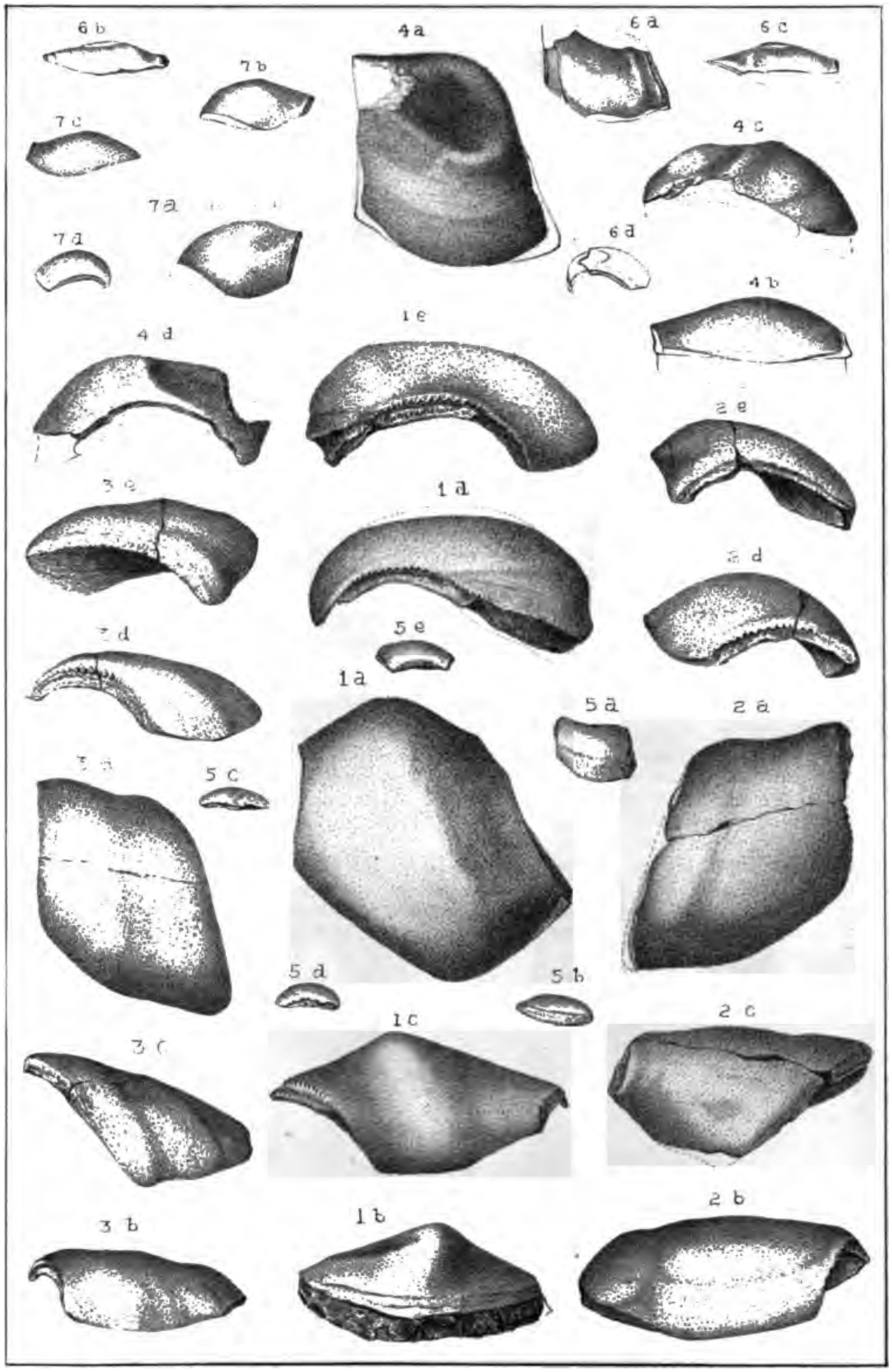

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PLATE II.

PAGE.

Fig. 1 PSEPHODUS LATUS, St. J. and W. 72

1 *a*. A small mandibular median tooth, seen from above, part of the coronal surface bordering the inner margin broken away; 1 *b*. do., transverse profile from inner margin; 1 *c*. do., from outer margin; 1 *d*. do., postero-lateral border; 1 *e*. do., antero-lateral border, showing longitudinal profile. St. Louis limestone; Alton, Illinois; Mr. Van Horne.

Fig. 2, *a*, *b*. *c*. *d*. *e*. Similar views of a very small example of the same form, left ramus, enlarged; 2 *f*. do., inferior surface. Same formation, locality and collection.

Fig. 3 *a*. A serial tooth, view from above; 3 *b*. do., outer margin transverse profile; 3 *c*. do., from the postero-lateral (?) border, longitudinal profile. St. L.; St. Louis, Missouri. O. St. John.

Fig. 4. PSEPHODUS LUNULATUS, St. J. and W. 74

Fig. 4 *a*. Views of tooth from above; 4 *b*. do., from the lateral border; 4 *c*. do., inner margin; 4 *d*. do., from the outer margin. Chester limestone; Chester. Ill. Dr. George Hambach.

PSEPHODUS PLACENTA. St. J. and W. 69

Fig. 5 *a*. A mature tooth referred to right ramus of mandible, from above; 5 *b*. do., from inner margin; 5 *c*. do., views from the anterior and the posterior border. Upper fish-bed, Kinderhook; Burlington, Iowa. Mr. Wachsmutn.

Fig. 6 *a*. *c*. *c*. *d*. Similar views of a smaller tooth, occupying the same position upon the jaw as the last. Same horizon and locality. Prof. Worthon.

Fig. 7 *a*. *b*. *c*. *d*. Similar views of an elongate individual of left ramus of upper jaw. Same formation, locality and collection.

Fig. 8 *a*. *b*. *c*. *d*. The same views of a small, short median tooth, referred to the right ramus of upper jaw, the coronal region much worn in front (the original of *Helodus placenta*). Same horizon, locality and collection.

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (Lower Carb.) PSEPHODI.

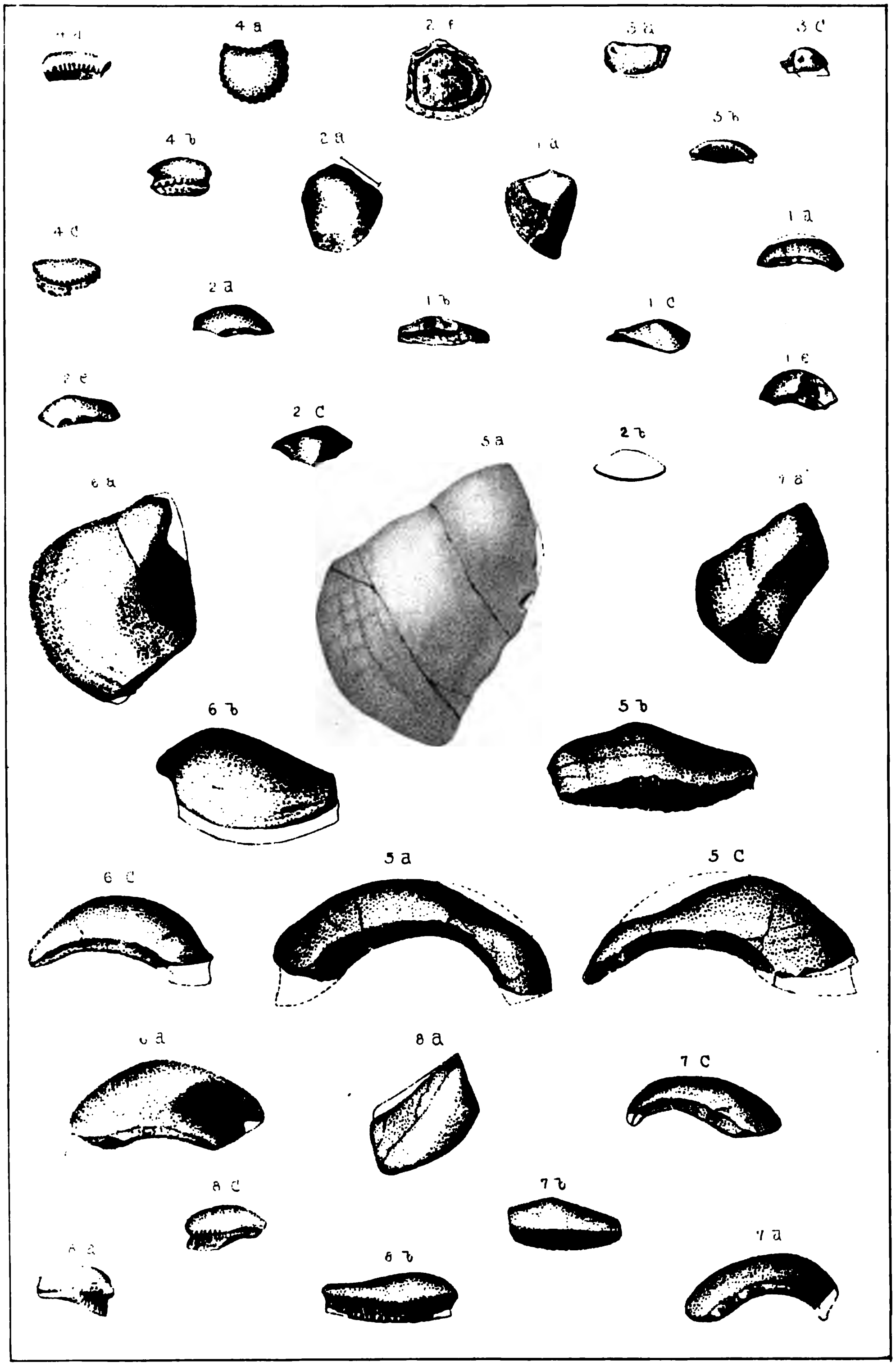

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PLATE III.

PAGE.

VATICINODUS VETUSTUS, St. J. and W. 82

Fig. 1 *a*. Maxillary posterior tooth left ramus, seen from above, the mutilated anterior border and posterior extremity restored in outline; 1 *b*, do., inner margin; 1 *c*, do., from the outer inrolled margin; 1 *d*, do., profile from posterior extremity. Kinderhook; DesMoines county, Iowa. O. St. John.

VATICINODUS DISCREPANS, St. J. and W. 83

Fig. 2 *a*. Maxillary posterior tooth, left ramus, from above, outline restored; 2 *b*, do., transverse profile from inner margin; 2 *c*, do., fore-shortened view from antero-lateral border. Buffington creek. Mr. Springer.

Fig. 3 *a*, *b*, *c*. Similar views of the same form, right ramus. Augusta. O. St. John.

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (Lower Carb.) COCHLIODONTS.

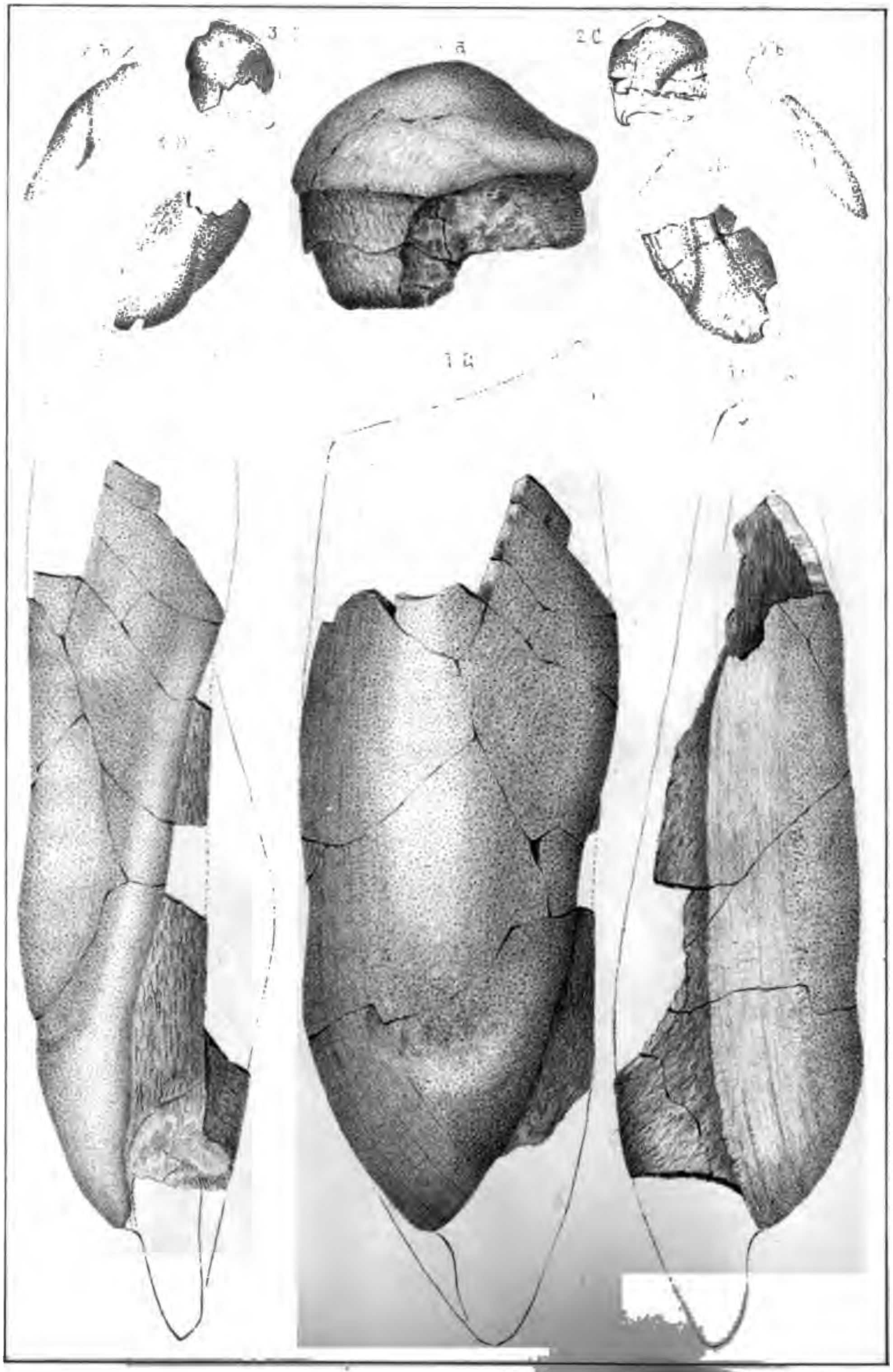

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PLATE IV—*Continued.*

PAGE.

16 *a.* **Mandibular posterior tooth, left ramus, an imperfect example, seen from above; 16 *b*. do., inner margin; 16 *c*, do., profile from anterior border. Keokuk limestone; Hamilton, Ill. Prof. Worthen.**

Fig. 17-19. VATICINODUS? SIMILIS, St. J. and W. 85

17 *a.* **A mature perfect posterior tooth of the right ramus of upper jaw, view from above; 17 *b*. do., inner margin; 17 *c*, do., outer inrolled margin; 17 *d*. do., foreshortened, from posterior extremity. Chester limestone; Evansville, Illinois. Dr. George Hambach.**

18 *a.* **An imperfect specimen of the same form, from left ramus, seen from above; 18 *b*, do., inner margin. Chester; Chester, Ill. Mr. Van Horne.**

19 *a.* **Mandibular posterior tooth, left ramus, seen from above, enlarged; 19 *b*, do., inner margin; 19 *c*, do., antero-lateral border. Chester; Chester, Ill. Prof. Worthen.**

Fig. 20. VATICINODUS? CARBONARIUS, St. J. and W. 83

20 *a.* **Maxillary posterior tooth, left ramus, seen from above, outline restored; 20 *b*, do., from inner margin. Lower Coal Measures; Carlinville, Ill. Prof. Worthen.**

Fig. 21. VATICINODUS? LEPIS, St. J. and W. 83

21 *a.* **Maxillary posterior tooth, right ramus, view from above, outline restored; 21 *b*, do., from inner margin, transverse profile. Upper Coal Measures; LaSalle, Ill. Prof. Worthen.**

Fig. 22-26. VATICINODUS? SIMPLEX, St. J. and W. 84

22 *a.* **Maxillary posterior tooth, right ramus, an imperfect specimen showing the posterior coronal contour, from above, enlarged; 22 *b*. do., inner margin; 22 *c*, do., outer margin. St. Louis limestone; Pella, Iowa. O. St. John.**

23 *a.* **Same form, left ramus, showing an entire tooth, coronal surface much worn, seen from above; 23 *b*. do., inner margin. St. Louis, Mo. O. St. John.**

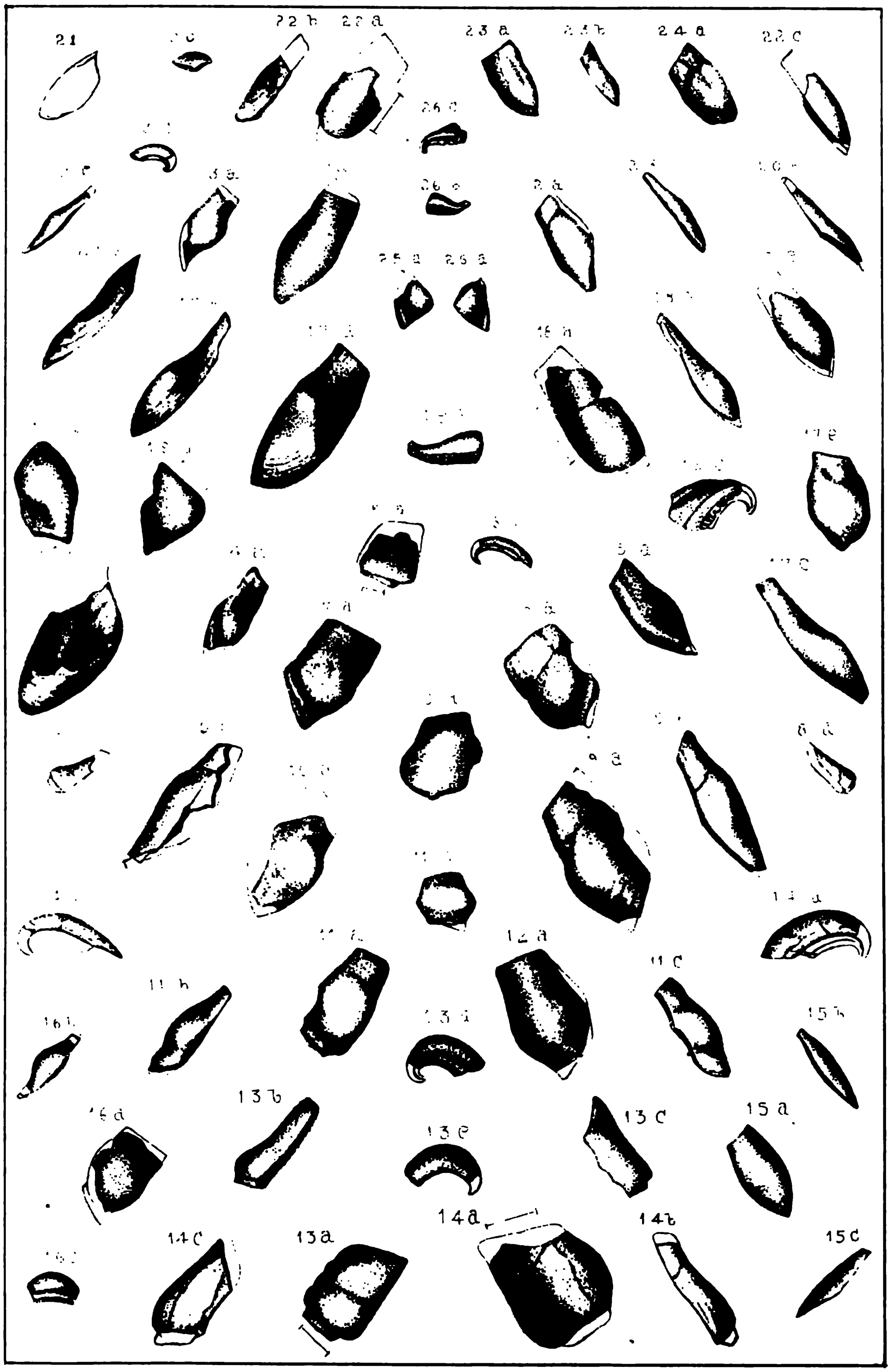
24 *a.* **A similar example, showing basal rim extending beyond coronal limits. St. Louis limestone; St. Louis, Mo. Prof. Worthen.**

25 *a.* **Mandibular posterior tooth, left ramus, view from above, outer extremity restored in outline. St. Louis limestone; Pella, Iowa. O. St. John.**

26 *a.* **A nearly entire example of same form, right ramus, seen from above; 26 *b*, do., inner margin; 26 *c*, do. antero-lateral border. St. Louis limestone; Pella. O. St. John.**

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (L. and U. Carb.) COCHLIODONTS.



A. H. Worthen, dirext. J. Mayer & Co. lith. Boston.

PLATE V.

PAGE.

Fig. 1. DELTOPTYCHIUS WACHSMUTHI, St. J. and W. 93

1 *a*. Posterior tooth of the left ramus of the mandible, viewed from above, broken extremity restored in outline; 1 *b* do., seen from the antero-lateral border; 1 *c* do., showing inner margin. Keokuk limestone, Warsaw, Ill. Coll. Prof. Worthen.

Fig. 2 *a*. A similar and more perfect tooth of the right ramus of the mandible, seen from above; 2 *b* do., antero-lateral border; 2 *c* do., postero-lateral border, Same formation, locality and collection.

Fig. 3 *a*. Posterior tooth of the left ramus of the upper jaw, from above; 3 *b*, do., profile from the inner margin. Same formation, locality and collection.

Fig. 4 *a*. Maxillary posterior tooth, right ramus, view from above; 4 *b* do., outer inrolled margin. Same formation, locality and collection.

Fig. 5 *a*. Maxillary posterior tooth and median series of teeth; 5 *b* do., right ramus, seen from above, outline restored. Keokuk limestone, Danville, Iowa. Coll. Mr. Wachsmuth.

DELTOPTYCHIUS PRIMUS, St. J. and W. 93

Fig. 6 *a*. Mandibular posterior tooth, left ramus, seen from above, outline restored. Upper Burlington fish-bed; Louisa Co., Iowa. Mr. Springer.

Fig. 7 *a*. Maxillary posterior tooth, right ramus, viewed from above, outline restored. Same horizon and locality. O. St. John.

Fig. 8 *a*. Maxillary posterior tooth, left ramus, from above. Same formation and locality. Mr. Springer.

DELTOPTYCHIUS EXPANSUS, St. J. and W. 98

Fig. 9 *a*. An imperfect posterior tooth of left ramus of mandible, showing coronal contour, seen from above, outline restored. St. Louis limestone; Alton, Ill. Coll. Mr. Van Horne.

Fig. 10 *a*. Mandibular posterior tooth, right ramus, seen from above. St. Louis limestone; St. Louis, Mo. Coll. Prof. Worthen.

Fig. 11 *a*. A large mandibular posterior tooth, from above, the coronal contour obscured by wear. St. Louis limestone; Waterloo, Ill. Coll. Prof. Worthen.

Fig. 12 *a*. Maxillary posterior tooth, right ramus, from above, outline restored. St. Louis limestone; Alton, Ill. Coll. Mr. Van Horne.

Fig. 13 *a*. Similar tooth, left ramus of upper jaw, view from above. Same formation, locality and collection.

DELTOPTYCHIUS VARSOVIENSIS, St. J. and W. 96

Fig. 14 *a*. Mandibular posterior tooth, left ramus, view from above, alate posterior border restored in outline; 14 *b* do., enlarged; 14 *c* do., showing antero-lateral border, enlarged; 14 *d* do., seen from the outer inrolled margin. Warsaw formation; above Alton, Ill. Mr. Van Horne.

Fig. 15 *a*. Maxillary posterior tooth, right ramus, seen from above. Warsaw formation; Warsaw, Ill.

DELTOPTYCHIUS NITIDUS, Leidy sp. 99

Fig. 16 *a*. Mandibular posterior tooth, left ramus, seen from above, outline restored; 16 *b* do., antero-lateral border; 16 *c* do., foreshortened view from postero-lateral border; 16 *d* do., outer inrolled extremity; 16 *e* do., inner margin. Chester limestone; Chester, Ill. Coll. Prof. Worthen.

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (Lower [illegible]) COCHLIODONTS.

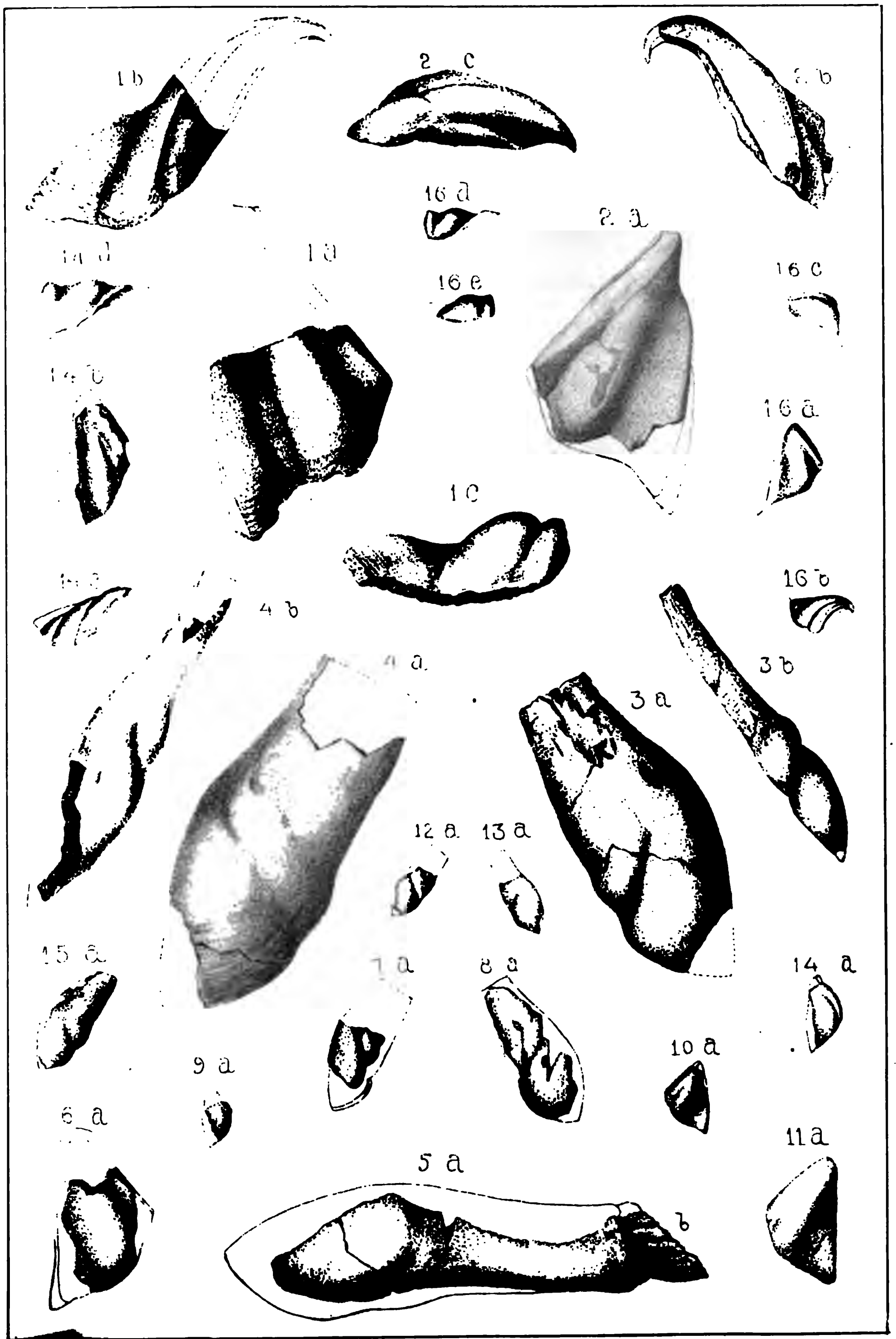


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PLATE VI.

Page.

Chitonodus libratus, St. J. and W. 119

Fig. 1 *a*. Maxillary posterior tooth, right ramus, view from above of an imperfect example, posterior extremity restored in outline; 1 *b*, do., from the inner margin. St. Louis limestone; Alton, Ill.

Chitonodus antiquus, St. J. and W. 116

Fig. 2 *a*. Mandibular posterior tooth, left ramus, view from above, outline partially restored; 2 *b*, do., transverse profile from inner margin; 2 *c*, do., outer inrolled margin; 2 *d*, do., from the antero-lateral border. Lower Burlington, Iowa. Prof. Worthen.

Chitonodus Springeri, St. J. and W. 112

Fig. 3 *a*. Maxillary posterior tooth, left ramus, view from above of a worn example, outline partially restored; 3 *b*, do., from inner margin; 3 *c*, do., outer inrolled margin; 3 *d*, do., from the anterior border, foreshortened. Upper Burlington; Augusta, Iowa. Mr. Wachsmuth.

Fig. 4 *a*. Same form, right ramus, a worn specimen, seen from above; 4 *b*, do., inner margin; 4 *c*, do., outer inrolled margin; 4 *d*, do., from anterior border, foreshortened. Upper Burlington; Louisa county, Iowa. Mr. Springer.

Fig. 5 *a*. Mandibular posterior tooth, left ramus, view from above; 5 *b*, do., inner margin; 5 *c*, do., from antero-lateral border; a worn example, showing merely a trace of transverse imbrications. Upper Burlington; Augusta, Iowa. O. St. John.

Fig. 6 *a*. A worn, medium-size example of the same form, seen from above; 6 *b*, do., inner margin; 6 *c*, do., outer inrolled margin; 6 *d*, do., from the anterior border. Upper Burlington; Augusta, Iowa. Mr. Springer.

Fig. 7 *a*. Mandibular median tooth, left ramus, a worn specimen, seen from above, outer extremity restored in outline; 7 *b*, do., inner margin, transverse profile; 7 *c*, do., outer margin; 7 *d*, do., from antero-lateral border; 7 *e*, do., postero-lateral border. Upper Burlington; Louisa county, Iowa. Mr. Springer.

Fig. 8 *a*, *b*, *c*, *d*, *e*. Similar views of a more prominently rigid, worn example of the same form, outline partially restored. Upper Burlington; Augusta, Iowa.

Fig. 9 *a*. Maxillary posterior tooth, left ramus, a medium-size example, preserving the transverse imbrications over a portion of the anterior neck, seen from above, outline partially restored; 9 *b*, do., inner margin, transverse profile; 9 *c*, do., from anterior border; 9 *d*, from posterior extremity. Upper Burlington; Louisa county, Iowa. O. St. John.

Fig. 10 *a*. A large, robust example of the same form, from above, partially restored in outline; 10 *b*, do., inner margin; 10 *c*, do., outer inrolled margin; 10 *d*, do., from anterior border, foreshortened. Upper Burlington; Augusta, Iowa.

Fig. 11 *a*. A similar example of the same form, seen from above, outline restored. Upper Burlington; Pleasant Grove, Iowa. Prof. Worthen.

Fig. 12 *a*. Mandibular posterior tooth, right ramus, showing transverse imbrications, view from above, outline restored. Upper Burlington; Louisa county, Iowa. O. St. John.

PLATE VI—*Continued.*

Fig. 13 *a*. A small example of the same form, left ramus, seen from above (represented too obliquely inrolled); 13 *b*, do., inner margin, transverse profile; 13 *c*, do., outer inrolled margin; 13 *d*, do., from anterior border. Upper Burlington; Pleasant Grove, Iowa.

Fig. 14 *a*. Mandibular median tooth, left ramus, showing imbrications, seen from above, outline restored; 14 *b*, do., inner margin, transverse profile; 14 *c*, do., outer margin; 14 *d*, do., from antero-lateral border; 14 *e*, do., postero-lateral border and longitudinal profile. Upper Burlington; Burlington, Iowa. O. St. John.

Fig. 15 *a*. A larger, worn example of the same form, from above, outline restored; 15 *b*, *c*, do., views from the antero and postero-lateral borders. Upper Burlington; Louisa county, Iowa. Mr. Springer.

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (Lower Carb.) COCHLIODONTS.

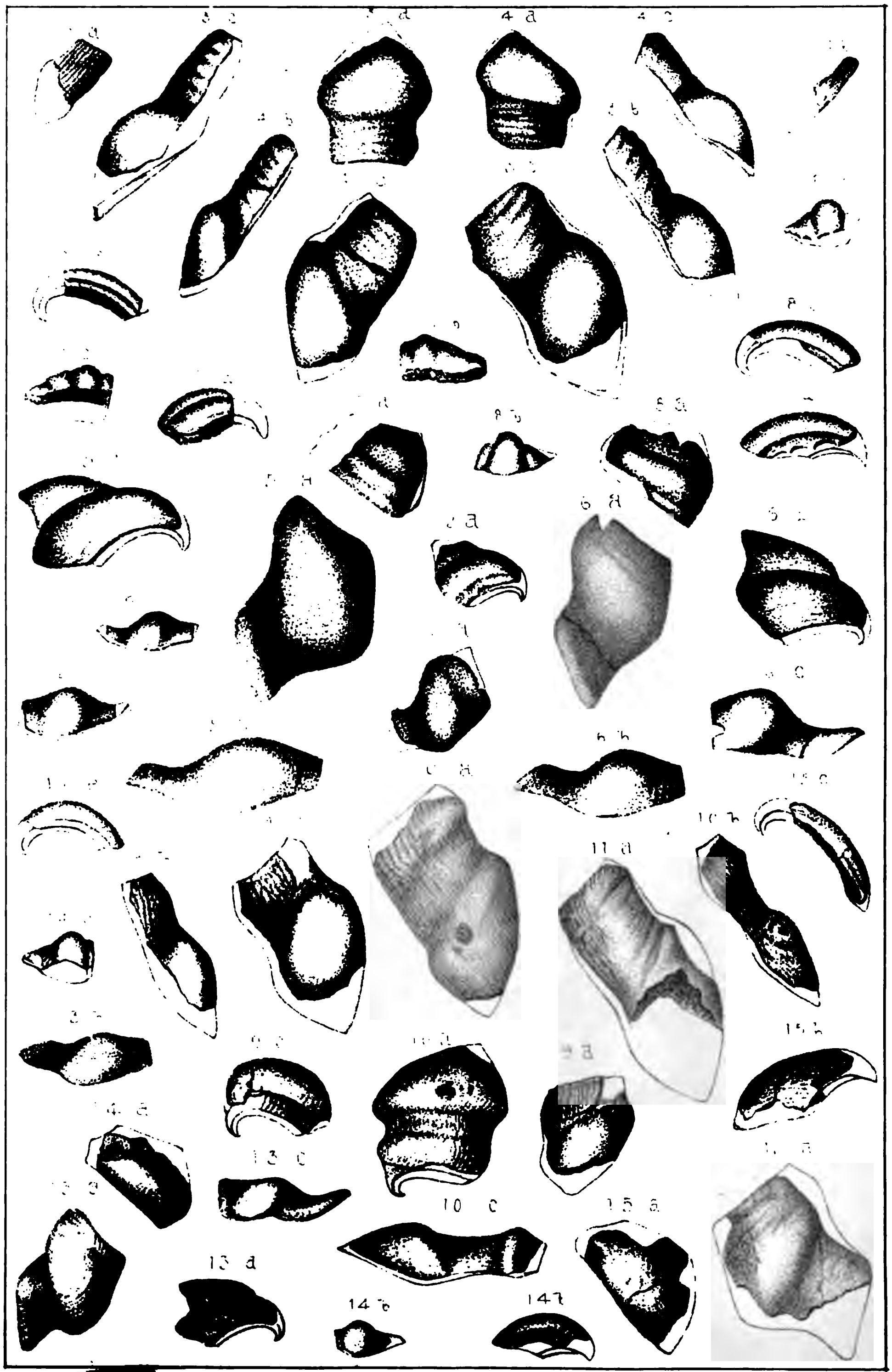

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PLATE VII—*Continued.*

PAGE.

CHITONODUS TRIBULIS, St. J. and W. 117

Fig. 18 *a*. Maxillary posterior tooth, left ramus, a large and nearly perfect example, seen from above; 18 *b* do., from the inner margin; 18 *c* do., outer inrolled margin; 18 *d* do., from antero-lateral border, foreshortened. Keokuk; Keokuk, Iowa. Mr. Cox.

Fig. 19 *a*. A small maxillary posterior tooth, left ramus, from above. Keokuk limestone; Warsaw, Ill. Prof. Worthen.

Fig. 20 *a*. A medium-size tooth of the same form, right ramus, from above, outline restored. Same formation. Bentonsport, Iowa. Mr. St. John.

Fig. 21 *a*. Mandibular posterior tooth, left ramus, a small example, seen from above; 21 *b* do., from inner margin; 21 *c* do., outer inrolled margin; 21 *d* do., from antero-lateral border. Keokuk; Keokuk, Iowa. Mr. Cox.

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (Lower Carb.) **COCHLIODONTS.**

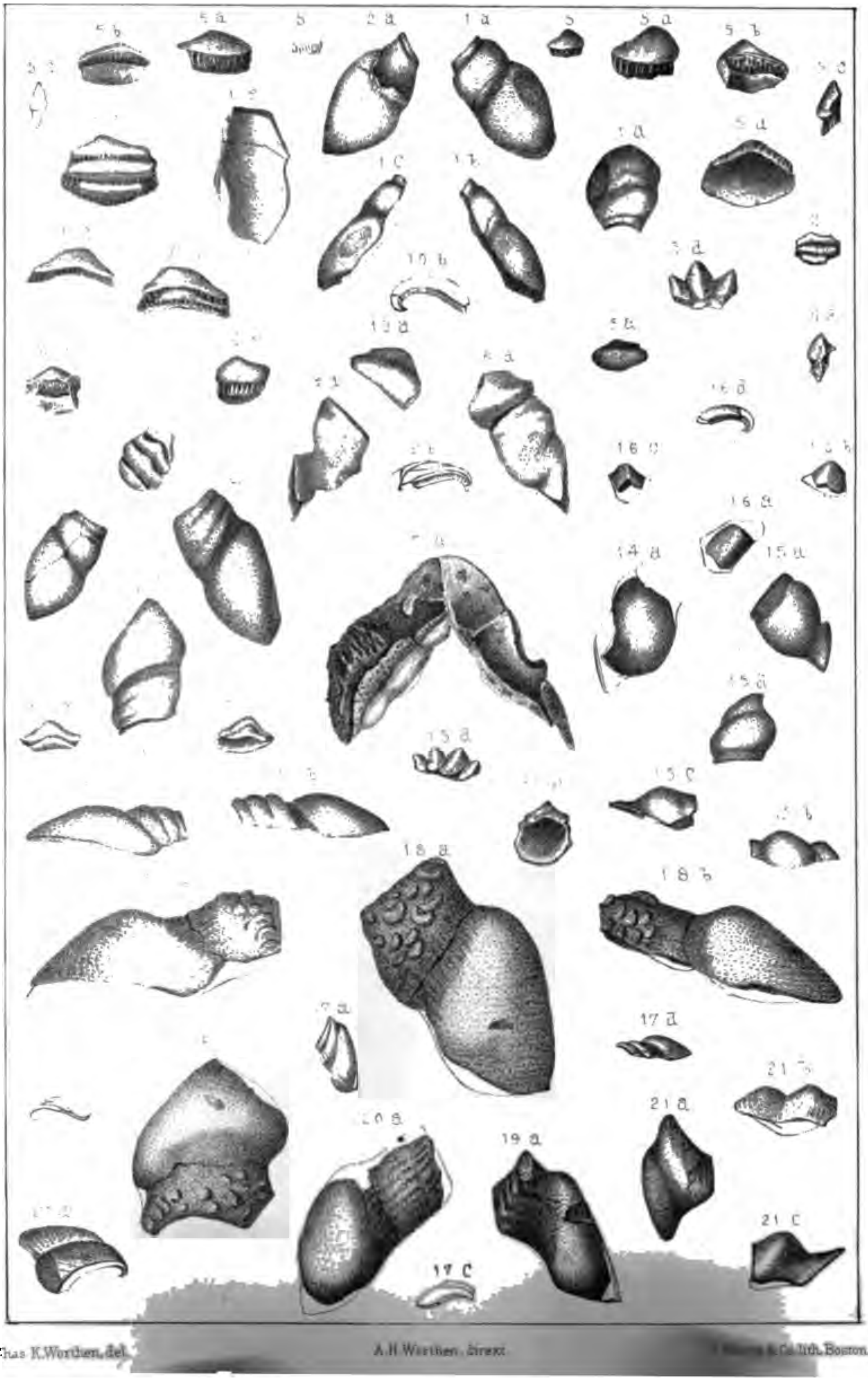

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PLATE VIII.

PAGE.

XYSTRODUS INCONDITUS, St. J. and W. 179

Fig. 1 *a*. Maxillary posterior tooth, left ramus, view from above, outline restored; 1 *b*, do., profile from antero-lateral border; 1 *c*, do., transverse section. Keokuk limestone; Warsaw, Illinois. Professor Worthen.

XYSTRODUS IMITATUS, St. J. and W. 180

Fig. 2 *a*. Maxillary posterior tooth, right ramus, from above; 2 *b*, do., longitudinal profile from antero-lateral border; 2 *c*, do., transverse section. St. Louis formation; Monroe county, Illinois. Professor Worthen.

XYSTRODUS BELLULUS, St. J. and W. 183

Fig. 3 *a*. Maxillary posterior tooth, left ramus, from above, outline restored; 3 *b*, do., longitudinal profile from the antero-lateral border; 3 *c*. do., transverse section. Coal No. 7, Ill. Gen'l. Sec; Danville, Illinois. Mr. Wm. Gurley.

XYSTRODUS SIMPLEX, St. J. and W. 178

Fig. 4 *a*. Mandibular posterior tooth, left ramus, view from above; 4 *b*, do., antero-lateral border; 4 *c*, do., from postero-lateral border; 4 *d*, do., inner margin; 4 *e*, do., outer inrolled margin. Upper Burlington limestone fish-bed; Monmouth, Illinois. Mr. Springer.

Fig. 5 *a*. Maxillary posterior tooth, right ramus, from above, outline restored; 5 *b*, do., from the antero-lateral border; 5 *c*, do., postero-lateral border; 5 *d*, do., transverse profile from inner margin; 5 *e*, do., outer inrolled extremity. Upper Burlington limestone, fish-bed; Louisa county, Iowa. Mr. Springer.

XYSTRODUS VERUS, St. J. and W. 181

Fig. 6 *a*. Mandibular posterior teeth, left ramus, view from above; 6 *b*, do., antero-lateral border, longitudinal profile; 6 *c*, do., transverse profile from inner margin; Chester limestone; Chester, Illinois. Professor Worthen.

Fig. 7 *a*. Maxillary posterior tooth, left ramus, from above; 7 *b*, do., longitudinal profile from the antero-lateral border; 7 *c*, do., from the postero-lateral border; 7 *d*, do., transverse profile from the inner margin. Same formation, locality and collection.

PŒCILODUS ST. LUDOVICI, St. J. and W. 132

Fig. 8 *a*. Mandible, with the pair of posterior teeth occupying their natural position, resting upon the granular osseus support, the right ramus showing the articular processes at the extremity. The anterior extremity of the jaw is mutilated, but it is evident whatever teeth it bore were extremely small; St. Louis limestone; Alton, Illinois. Mr. W. C. Van Horne.

Fig. 9 *a*. Mandibular posterior tooth, right ramus, view from above. Same formation, locality and collection.

Fig. 10 *a*. The same form, left ramus, view from above; 10 *b*, do., outer inrolled margin; 10 *c*, do., from inner margin. Same formation, locality and collection.

Fig. 11 *a*. Maxillary posterior tooth, right ramus, from above; 11 *b*, do., from the outer margin. St. Louis formation; Pella, Iowa. Mr. St. John.

Fig. 12 *a*. Same form, left ramus, from above; 12 *b*, do., from inner margin; 12 *c*, do., from antero-lateral border, foreshortened; St. Louis; Alton, Illinois. Professor Worthen.

PLATE VIII—*Continued*

PAGE.

PŒCILODUS VARSOVIENSIS, St. J. and W. 131

Fig. 13 *a*. Maxillary posterior tooth, left ramus, seen from above anterior border restored in outline, enlarged one diameter; Warsaw; above Alton, Illinois. Mr. Van Horne.

Fig. 14 *a*. A larger example of the same form, view from above, anterior portion of crown mutilated; 14 *b*, do., transverse profile from inner margin. Same formation, locality and collection.

PŒCILODUS CHESTERENSIS, St. J. and W................ 135

Fig. 15 *a*. Maxillary posterior tooth, right ramus, from above, outline partially restored; 15 *b*, do., from the inner margin; 15 *c*, do., outer inrolled margin; Chester; Chester, Illinois. Mr. Van Horne.

Fig. 16 *a*. Mandibular posterior tooth, left ramus, view from above; 16 *b*, do., inner margin; 16 *c*, do., outer inrolled margin; 16 *d*, do., profile from antero-lateral border; Chester; Chester, Illinois. Professor Worthen.

Fig. 17 *a*. A small example of the same form, right ramus, from above, showing the transverse corrugations; Chester; Chester, Illinois. Professor Worthen.

PŒCILODUS WORTHENI, St. John....................................... 136

Fig. 18 *a*. Mandibular posterior tooth, left ramus, view from above, outline partially restored; 18 *b*, do., transverse profile from inner margin; 18 *c*, do., outer inrolled margin; 18 *d*, do., longitudinal profile antero-lateral border; Chester; Chester, Illinois.

PŒCILODUS SPRINGERI, St. J. and W.................................. 138

Fig. 19 *a*. Mandibular posterior tooth, left ramus, view from above, outline partially restored; 19 *b*, do., transverse profile from inner margin; 19 *c*, do., outer inrolled margin; Lower Carboniferous; Santa Fe, New Mexico. Messrs. Springer and St. John.

PŒCILODUS CARBONARIUS, St. J. and W................................ 139

Fig. 20 *a*. Mandibular posterior tooth, right ramus, view from above, outline partially restored; 20 *b*, do., transverse profile from inner margin outline; 20 *c*, do., outer inrolled margin; 20 *d*, do., outline profile from antero-lateral border; Upper Coal Measures; LaSalle, Illinois. Professor Worthen.

Fig. 21 *a*. Maxillary posterior tooth, right ramus, seen from above, outline restored; 21 *b*, do., profile from inner margin; 21 *c*, do., outer inrolled margin. Same formation, locality and collection. Professor Worthen.

PLATE VIII.

PAGE.

Xystrodus inconditus, St. J. and W. 179

Fig. 1 *a*. Maxillary posterior tooth, left ramus, view from above, outline restored; 1 *b*, do., profile from antero-lateral border; 1 *c*, do., transverse section. Keokuk limestone; Warsaw, Illinois. Professor Worthen.

Xystrodus imitatus, St. J. and W. 180

Fig. 2 *a*. Maxillary posterior tooth, right ramus, from above; 2 *b*, do., longitudinal profile from antero-lateral border; 2 *c*, do., transverse section. St. Louis formation; Monroe county, Illinois. Professor Worthen.

Xystrodus bellulus, St. J. and W. 183

Fig. 3 *a*. Maxillary posterior tooth, left ramus, from above, outline restored; 3 *b*, do., longitudinal profile from the antero-lateral border; 3 *c*. do., transverse section. Coal No. 7, Ill. Gen'l. Sec; Danville, Illinois. Mr. Wm. Gurley.

Xystrodus simplex, St. J. and W. 178

Fig. 4 *a*. Mandibular posterior tooth, left ramus, view from above; 4 *b*, do., antero-lateral border; 4 *c*, do., from postero-lateral border; 4 *d*, do., inner margin; 4 *e*, do., outer inrolled margin. Upper Burlington limestone fish-bed; Monmouth, Illinois. Mr. Springer.

Fig. 5 *a*. Maxillary posterior tooth, right ramus, from above, outline restored; 5 *b*, do., from the antero-lateral border; 5 *c*, do., postero-lateral border; 5 *d*, do., transverse profile from inner margin; 5 *e*, do., outer inrolled extremity. Upper Burlington limestone, fish-bed; Louisa county, Iowa. Mr. Springer.

Xystrodus verus, St. J. and W. 181

Fig. 6 *a*. Mandibular posterior teeth, left ramus, view from above; 6 *b*, do., antero-lateral border, longitudinal profile; 6 *c*, do., transverse profile from inner margin; Chester limestone; Chester, Illinois. Professor Worthen.

Fig. 7 *a*. Maxillary posterior tooth, left ramus, from above; 7 *b*, do., longitudinal profile from the antero-lateral border; 7 *c*, do., from the postero-lateral border; 7 *d*, do., transverse profile from the inner margin. Same formation, locality and collection.

Pœcilodus St. Ludovici, St. J. and W. 132

Fig. 8 *a*. Mandible, with the pair of posterior teeth occupying their natural position, resting upon the granular osseus support, the right ramus showing the articular processes at the extremity. The anterior extremity of the jaw is mutilated, but it is evident whatever teeth it bore were extremely small; St. Louis limestone; Alton, Illinois. Mr. W. C. Van Horne.

Fig. 9 *a*. Mandibular posterior tooth, right ramus, view from above. Same formation, locality and collection.

Fig. 10 *a*. The same form, left ramus, view from above; 10 *b*, do., outer inrolled margin; 10 *c*, do., from inner margin. Same formation, locality and collection.

Fig. 11 *a*. Maxillary posterior tooth, right ramus, from above; 11 *b*, do., from the outer margin. St. Louis formation; Pella, Iowa. Mr. St. John.

Fig. 12 *a*. Same form, left ramus, from above; 12 *b*, do., from inner margin; 12 *c*, do., from antero-lateral border, foreshortened; St. Louis; Alton, Illinois. Professor Worthen.

Plate VIII—*Continued*.

PAGE.

Pœcilodus Varsoviensis, St. J. and W. 121

Fig. 13 *a*. Maxillary posterior tooth, left ramus, seen from above anterior border restored in outline, enlarged one diameter; Warsaw; above Alton, Illinois. Mr. Van Horne.

Fig. 14 *a*. A larger example of the same form, view from above, anterior portion of crown mutilated; 14 *b*, do., transverse profile from inner margin. Same formation, locality and collection.

Pœcilodus Chesterensis, St. J. and W. 125

Fig. 15 *a*. Maxillary posterior tooth, right ramus, from above, outline partially restored; 15 *b*, do., from the inner margin; 15 *c*, do., outer inrolled margin; Chester; Chester, Illinois. Mr. Van Horne.

Fig. 16 *a*. Mandibular posterior tooth, left ramus, view from above; 16 *b*, do., inner margin; 16 *c*, do., outer inrolled margin; 16 *d*, do., profile from antero-lateral border; Chester; Chester, Illinois. Professor Worthen.

Fig. 17 *a*. A small example of the same form, right ramus, from above, showing the transverse corrugations; Chester; Chester, Illinois. Professor Worthen.

Pœcilodus Wortheni, St. John.. 126

Fig. 18 *a*. Mandibular posterior tooth, left ramus, view from above, outline partially restored; 18 *b*, do., transverse profile from inner margin; 18 *c*, do., outer inrolled margin; 18 *d*, do., longitudinal profile antero-lateral border; Chester; Chester, Illinois.

Pœcilodus Springeri, St. J. and W. 128

Fig. 19 *a*. Mandibular posterior tooth, left ramus, view from above, outline partially restored: 19 *b*, do., transverse profile from inner margin; 19 *c*, do., outer inrolled margin; Lower Carboniferous; Santa Fe, New Mexico. Messrs. Springer and St. John.

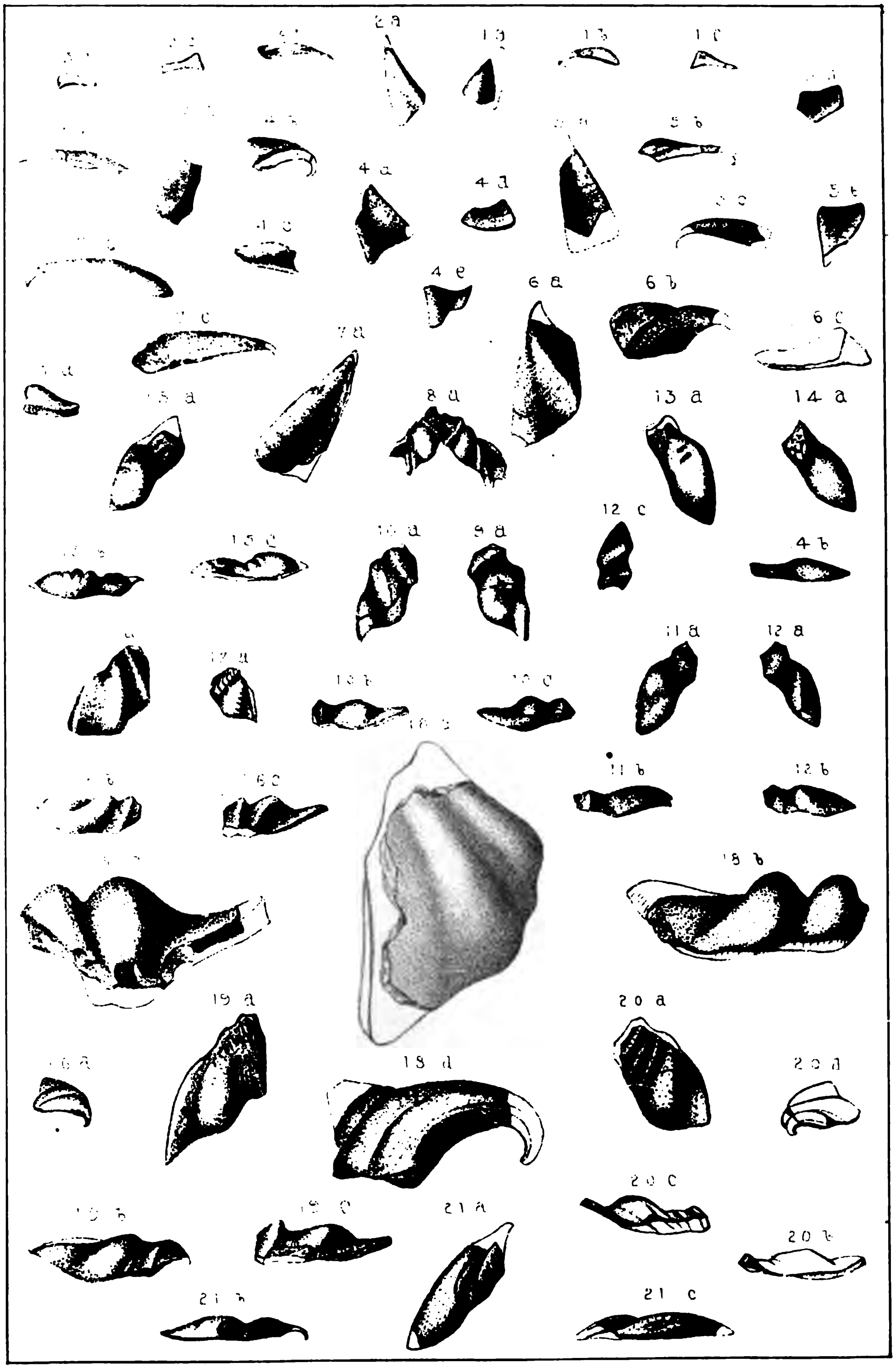
Pœcilodus carbonarius, St. J. and W. 129

Fig. 20 *a*. Mandibular posterior tooth, right ramus, view from above, outline partially restored; 20 *b*, do., transverse profile from inner margin outline; 20 *c*, do., outer inrolled margin; 20 *d*, do., outline profile from antero-lateral border; Upper Coal Measures; LaSalle, Illinois. Professor Worthen.

Fig. 21 *a*. Maxillary posterior tooth, right ramus, seen from above, outline restored; 21 *b*, do., profile from inner margin; 21 *c*, do., outer inrolled margin. Same formation, locality and collection. Professor Worthen.

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (Lower Carb.) COCHLIODONTS.



Chas F. Worthen, del. A. H. Worthen, direxit. J. Mayer & Co. lith Boston.

PLATE IX.

PAGE.

DELTODUS PARVUS. St. J. and W. 151

Fig. 1 *a*. Mandibular posterior tooth, left ramus, from above, enlarged; 1 *b*. do., profile from antero-lateral border; 1 *c*. do., from postero-lateral border. St. Louis; Pella, Iowa. Mr. St. John.

Fig. 2 *a*. Same form, right ramus, enlarged. Same formation, locality and collection.

Fig. 3 *a*. Outline of a mandibular median tooth, left ramus, from above, enlarged. St. Louis; St. Louis, Mo. Mr. St. John.

Fig. 4 *a*. Maxillary posterior tooth, right ramus, from above, enlarged; 4 *b*. do., transverse profile from inner margin; 4 *c*. do., longitudinal profile from antero-lateral border, extremity restored in outline. St. Louis, Pella, Iowa. Mr. Van Horne.

Fig. 5 *a*. *b*. *c*. Similar views of the same form, left ramus, showing a perfect example. Same formation and locality. Mr. St. John.

DELTODUS CINCTULUS, St. J. and W. 146

Fig. 6 *a*. Mandibular posterior tooth, left ramus, view from above, extremity restored in outline; 6 *b*. do., from inner margin, transverse profile; 6 *c*. do., antero-lateral border, longitudinal profile. Warsaw beds; Madison county, Ill. Prof. Worthen.

Fig. 7 *a*. *b*. *c*. Similar views of a maxillary posterior tooth, left ramus. Barrett's Station, Mo. Prof. Worthen.

DELTODUS TRILOBUS. St. J. and W. 148

Fig. 8 *a*. Mandibular median tooth, left ramus, view from above; 8 *b*., do., from inner margin; 8 *c*. do., from outer margin, extremity broken away; 8 *d*. do., longitudinal profile from antero-lateral border; 8 *e*. do., from postero-lateral border; 8 *f*. transverse section, showing prominent definition of the anterior and posterior lobes. Warsaw limestone; Jersey county, Ill. Prof. Worthen.

DELTODUS OCCIDENTALIS (Leidy, sp.) 150

Fig. 9 *a*. Maxillary posterior tooth, left ramus, from above. St. Louis limestone; Monroe county, Ill. Prof. Worthen.

Fig. 10 *a*. Mandibular median tooth, right ramus, from above, outer extremity broken away; 10 *b*. do., from antero-lateral border; 10 *c*. do., postero-lateral border; 10 *d*. do., transverse section. Warsaw beds; Warsaw, Ill. Prof. Worthen.

DELTODUS LATIOR. St. J. and W. 145

Fig. 11 *a*. Medium-size tooth of the mandibular posterior form, right ramus, from above. Keokuk; Hamilton, Ill. Prof. Worthen.

Fig. 12 *a*. A smaller individual of the same form; same locality.

Fig. 13 *a*. *b*. *c*. DELTODOS CINGULATUS, N. and W. ....

(Geol. Surv. of Ill., Vol. II, p. 99, Pl. IX, fig. 6.)

13 *a*. Maxillary posterior tooth, left ramus, from above; 13 *b*. from antero-lateral border; 13 *c*. outline from inner margin, transverse profile. Chester limestone; Chester, Ill. Prof. Worthen.

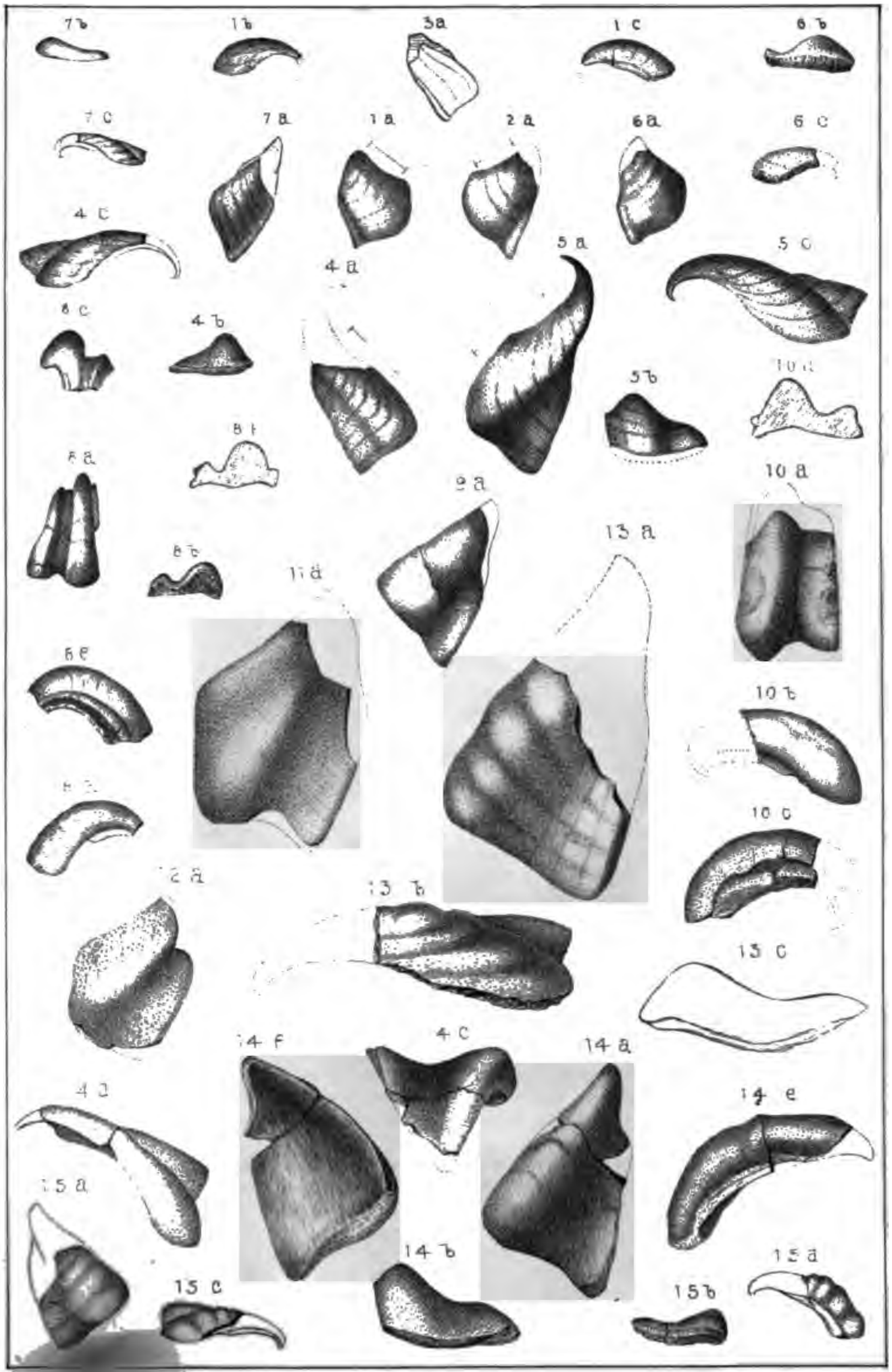
DELTODUS INTERMEDIUS. St. J. and W. 153

Fig. 14 *a*. Maxillary posterior tooth, left ramus, from above; 14 *b*. do., transvere profile from inner margin; 14 *c*. do., from outer margin; 14 *d*. do., from antero-lateral border, longitudinal profile; 14 *e*. do., from postero-lateral border; 14 *f*. do., showing inferior surface. St. Louis formation; Pella, Iowa. Mr. St. John.

Fig. 15 *a*. *b*. *c*. *d*. Similar views of a small example of the same form, right ramus, showing a marked undulated coronal surface. St. Louis; Columbia, Monroe county, Ill. Prof. Worthen.

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (Lower Carb.) **COCHLIODONTS.**



Chas E.W

A.H. Worthen, dirext.

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PLATE X.

PAGE.

DELTODUS POWELLII, St. J. and W. 154

Fig. 1 *a*. Mandibular posterior tooth, left ramus, view from above; 1 *b*, do., transverse profile, outline from inner margin; 1 *c*, do., from outer margin, outline; 1 *d*, do., outline from antero-lateral border; 1 *e*, do., from postero-lateral border; 1 *f*, showing character of punctation of coronal surface, enlarged. Carboniferous limestone; Utah. National Museum.

Fig. 2 *a*, *b*, *c*, *d*. *Deltodus Mercurii*, Newb. Lower Carb.; Santa Fe, New Mexico, O. St. John.

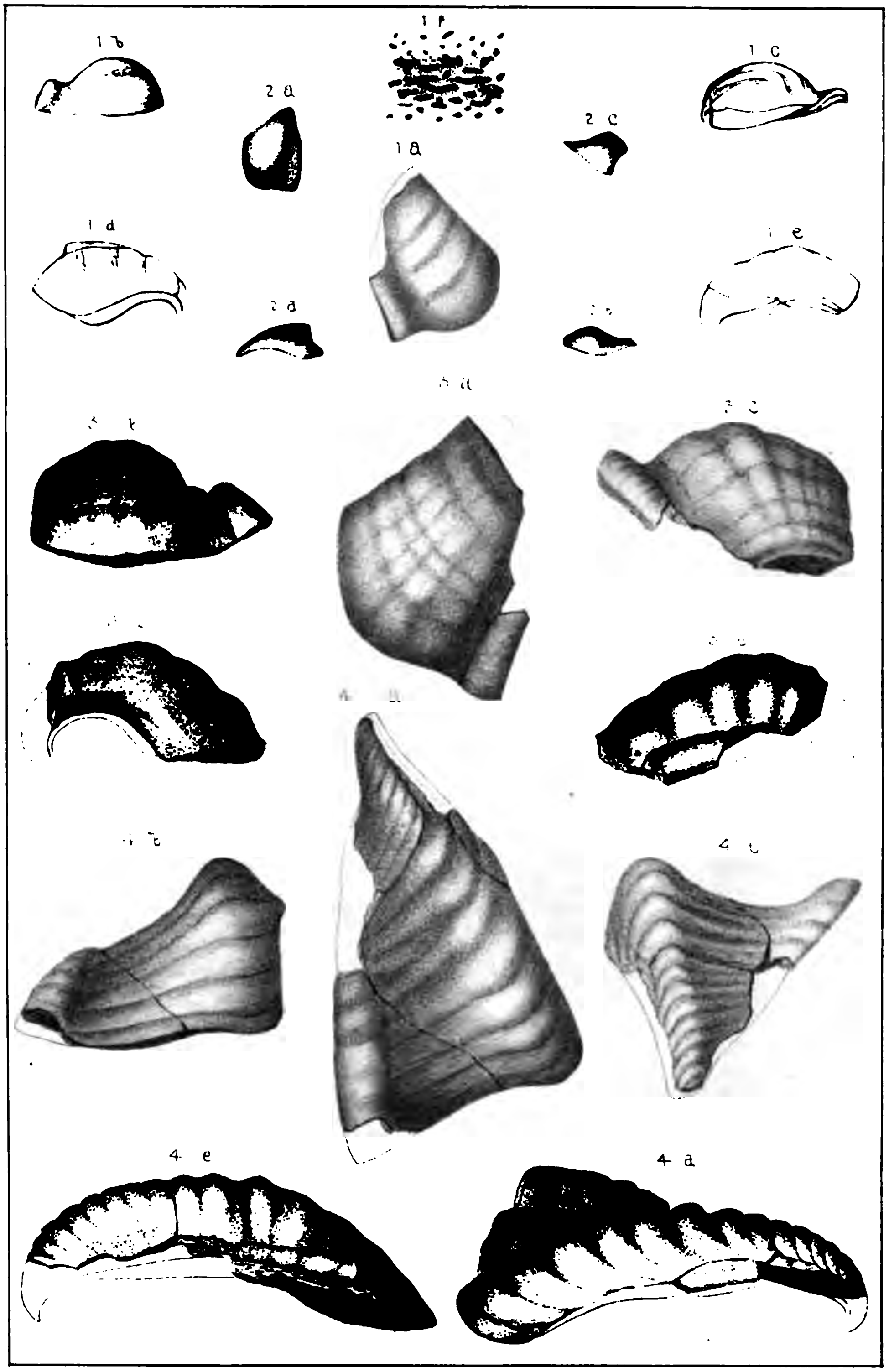
DELTODUS PROPINQUUS, St. J. and W. 156

Fig. 3 *a*. Mandibular posterior tooth, right ramus, view from above; 3 *b*, do., transverse profile from inner margin; 3 *c*, do., from outer margin; 3 *d*, do., longitudinal profile from antero-lateral border; 3 *e*, do., postero-lateral border. Coal No. 5, Carlinville, Ill.

Fig. 4 *a*, *b*, *c*, *d*, *e*. Similar views of a maxillary posterior tooth, right ramus. Coal No. 5, Carlinville, Ill., Mr. Alex. Butters.

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (U. and L. Carb.) **COCHLIODONTS.**



Chas. K. Worthen, del. A.H. Worthen, direxit. J. Mayer & Co. lith. Boston

PLATE XI—*Continued.*

PLATE.

DELTODOPSIS EXORNATUS, ? St. J. and W. 168

Fig. 14 *a*. Mandibular posterior tooth, right ramus, view from above, outline of alate posterior border restored; 14 *b*, do., longitudinal profile from the antero-lateral border. Warsaw: above Alton, Mr. Van Horne.

Fig. 15. DELTODOPSIS ? BIALVEATUS, St. J. and W. 169

Fig. 15 *a*. Mandibular median tooth, left ramus, view from above; 15 *b*, do., transverse profile from inner margin; 15 *c*, do., from the outer extremity: 15 *d*, do., inferior surface; 15 *e*, do., antero-lateral border; 15 *f*, do., postero-lateral border. U. Burlington; Louisa county, Iowa, Mr. St. John.

Fig. 16. D. ? KEOKUK, St. J. and W. 169

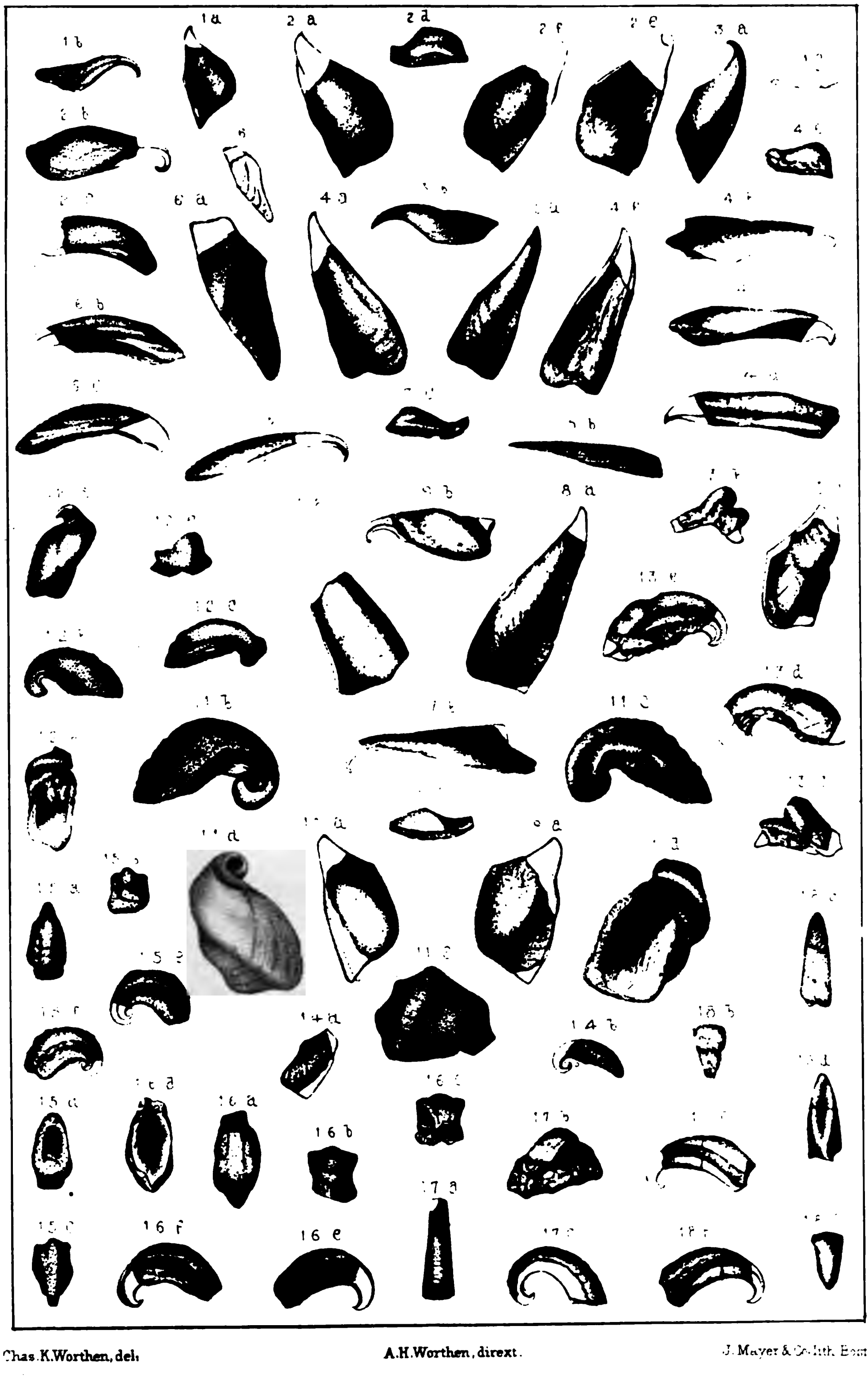
Fig. 16 *a*, *b*, *c*, *d*, *e*, *f*. Mandibular median tooth, left ramus, same views as above. Keokuk limestone.

Fig. 17. *D. ? convexus.* 17 *a*, Mandibular median tooth, left ramus, from above; 17 *b*, do., from inner margin; 17 *c*, do., antero-lateral border, basal rim restored in outline. U. Burlington; Louisa county, Iowa, Mr. Springer.

Fig. 18. *D. ? convexus.* 18 *a*, Mandibular median tooth, right ramus, seen from above; 18 *b*, do., transverse profile from inner margin; 18 *c*, do., outer extremity; 18 *d*, do., inferior surface; 18 *e*, *f*, antero- and postero-lateral borders. U. B.: Louisa county, Iowa, O. St. J.

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES.   (Lower Carb.)   **COCHLIODONTS.**



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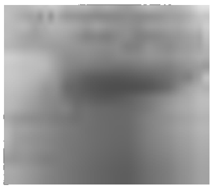


PLATE XII.

PAGE.

SANDALODUS COMPLANATUS, (N and. W sp.)..............................184

Fig. 1 *a*. Mandibular posterior tooth, left ramus, outer extremity and posterior border restored in outline; 1 *b* do., antero-lateral border; 1 *c* do., inner margin and transverse profile. Upper Burlington; Burlington, Iowa. Mr. Wachsmuth.

Fig. 2 *a*. Maxillary posterior tooth, right ramus, from above, partially restored in outline; 2 *b* do., longitudinal profile from antero-lateral border. Upper Burlington; Pleasant Grove, Iowa. Prof. Worthen.

Fig. 3 *a*. Mandibular median tooth, left ramus, a large example from above; 3 *b* do., postero-lateral border and longitudinal profile; 3 *c* do., antero-lateral border; 3 *d* do., inner-margin and transverse profile; 3 *e* do., outer extremity, mutilated; 3 *f* do., showing the concave inferior surface. Upper Burlington; Louisa Co., Iowa. Mr. Springer.

Fig. 4 *a*. A small example of the same form, seen from above; 4 *b* do., longitudinal profile from postero-lateral border. Same formation, locality and collection.

SANDALODUS, sp?.. 187

Fig. 5 *a*. Mandibular posterior tooth, left ramus, from above, partially restored in outline; 5 *b* do., longitudinal profile from antero-lateral border; 5 *c* do., from the postero-lateral border. Warsaw limestone; Warsaw, Ill. Prof. Worthen.

Fig. 6 *a*. Maxillary posterior tooth, left ramus, seen from above, outline partially restored; 6 *b* do., longitudinal profile from antero-lateral border; 6 *c* do., from outer extremity. Warsaw limestone; Piasa creek, above Alton. Mr. Van Horne.

SANDALODUS SPATULATUS, (N and. W. sp.)..............................188

Fig. 7 *a*. Mandibular median tooth, left ramus, view from above, outer extremity mutilated from wear; 7 *b* do., longitudinal profile from postero-lateral border; 7 *c* do., antero-lateral border; 7 *d* do., transverse profile from inner margin; 7 *e* do., outer margin; 7 *f* do., inferior surface. St. Louis limestone: Alton, Ill. Mr. Van Horne.

SANDALODUS LÆVISSIMUS, (N. and W.)..................................186

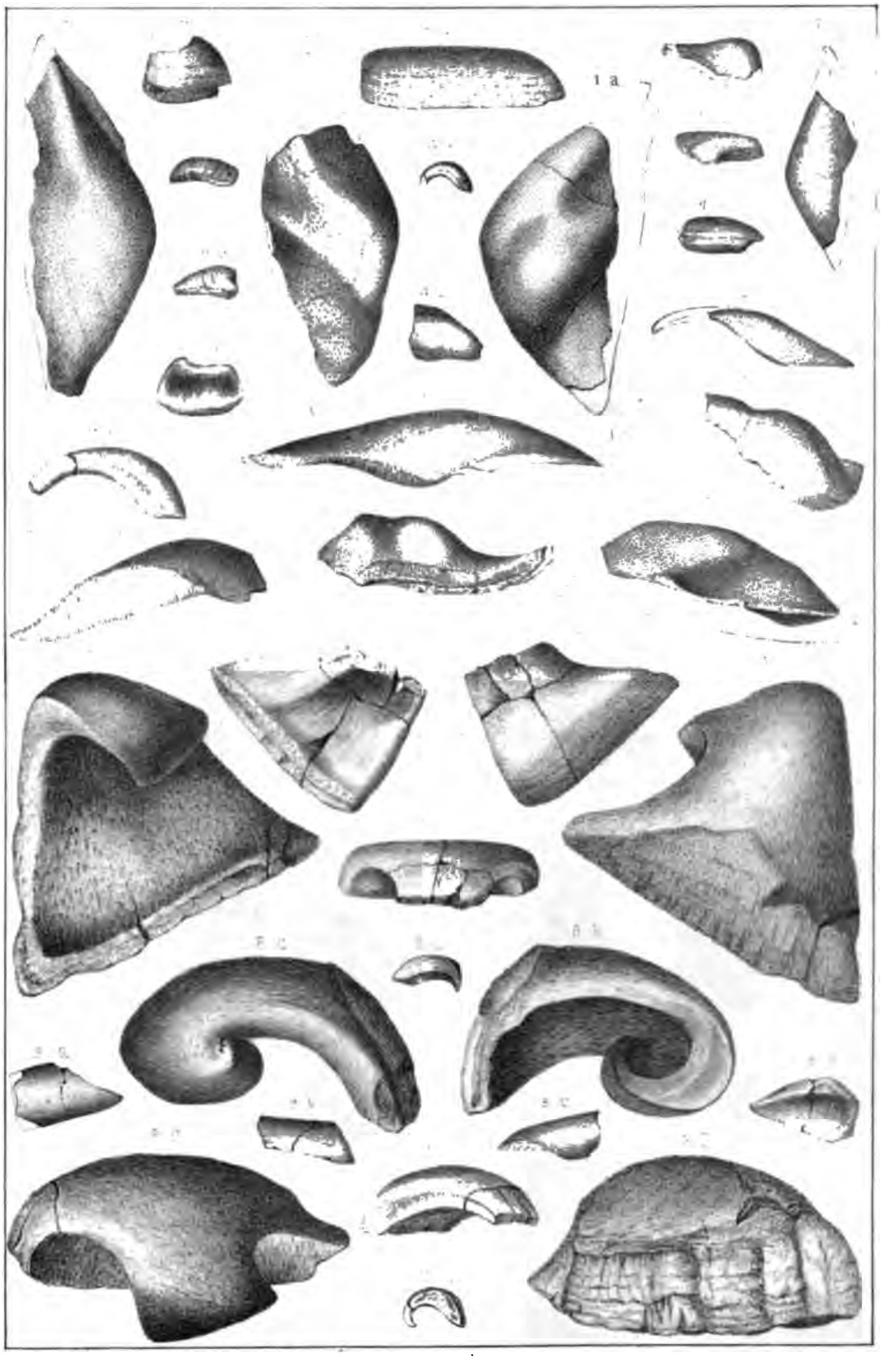
Fig. 8 *a*. Mandibular median tooth, right ramus, view from above of a very large example, the greater part of the coronal surface excessively worn from use; 8 *b* do., postero-lateral border; 8 *c* do., antero-lateral border; 8 *d* do., inner margin; 8 *e* do., outer inrolled margin; 8 *f* do., inferior aspect, showing inrolled outer extremity. Keokuk limestone; Keokuk, Iowa. Mr. Cox.

Fig. 9 *a*. A small specimen of the same form, left ramus, seen from above; 9 *b* do., inner margin and transverse profile; 9 *c* do., outer margin; 9 *d* do., antero-lateral border; 9 *e* do., postero-lateral border and longitudinal profile; 9 *f* do., inferior surface. Keokuk limestone; Keokuk, Iowa. Mr. Van Horne.

Pl. XI.

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (Lower Carb.) **COCHLIODONTS.**



E. Worthen del. A.H. Worthen, dirext. J. Mayer & Co. lith. Boston.

PLATE XIII.

PAGE.

ORTHOPLEURODUS NOVO MEXICANUS, St. J. & W........................ 195

Fig. 1 *a*. Maxillary posterior tooth, left ramus, view from above, outline partially restored; 1 *b*. do., profile from the straight border. Lower Carboniferous; Santa Fe, New Mexico. Messrs. Springer and St. John.

Fig. 2 *a*, *b*. Similar views of the same form of right ramus. Same formation, locality and collection.

Fig. 3 *a*. Mandibular posterior tooth, left ramus, seen from above, outline restored; 3 *b*. do., inner margin, transverse profile; 3 *c*. do., longitudinal profile from the antero-lateral border. Same formation, locality and collection.

ORTHOPLEURODUS CONVEXUS, St. J. and W.............................. 193

Fig. 4 *a*. Mandibular posterior tooth, right ramus, view from above, outline restored; 4 *b*. do., longitudinal profile from antero-lateral border; 4 *c*. do., transverse profile from inner margin. Strata above the Mahoning Sandstone Coal-Measures; Morgantown, West Virginia. Prof. Worthen.

Fig. 5 *a*. Maxillary posterior tooth, left ramus, view from above, restored in outline; 5 *b*. do., profile from the straight border. Same formation, locality and collection.

ORTHOPLEURODUS CARBONARIUS, (N. and W. sp.)........................ 192

Fig. 6 *a*. Maxillary posterior tooth, left ramus, a small, well-preserved example, seen from above, outline partially restored.

Fig. 7 *a*. Mandibular posterior tooth, left ramus, a similarly preserved specimen, from above.

Fig. 8 *a*. Mandibular median tooth, left ramus, view from above, outline partially restored. Lower Coal-Measures, roof of Coal No. 5; Bloomington, Ills. Mr. L. A. Fuller.

NOTE: The three above specimens were associated on a bit of carbonaceous shale in such a manner as to leave scarcely a doubt that they pertained to one and the same individual. St. John.

TENIODUS FACIATUS, (N. and W. sp.)................................ 76

Fig. 9 *a*. Maxillary posterior tooth, right ramus, view from above, restored in out line; 9 *b*. do., transverse profile from inner margin; 9 *c*. do., outer inrolled margin; 9 *d*. do., from tne antero-lateral border; 9 *e*. do., postero-lateral border. Provisionally identified with the above species. Warsaw limestone; above Alton, Ill. Mr. Van Horne.

TENIODUS OBLIQUUS, St. J. and W.................................... 78

Fig. 10 *a*. Maxillary posterior tooth, right ramus from above, outline restored; 10 *b*. do., transverse profile from inner margin; 10 *c*. do., longitudinal profile from antero-lateral border; 10 *d*. do., postero-lateral border. Chester limestone; Chester, Ills. Dr. Hambach.

TENIODUS REGULARIS, St. J. and W................................... 77

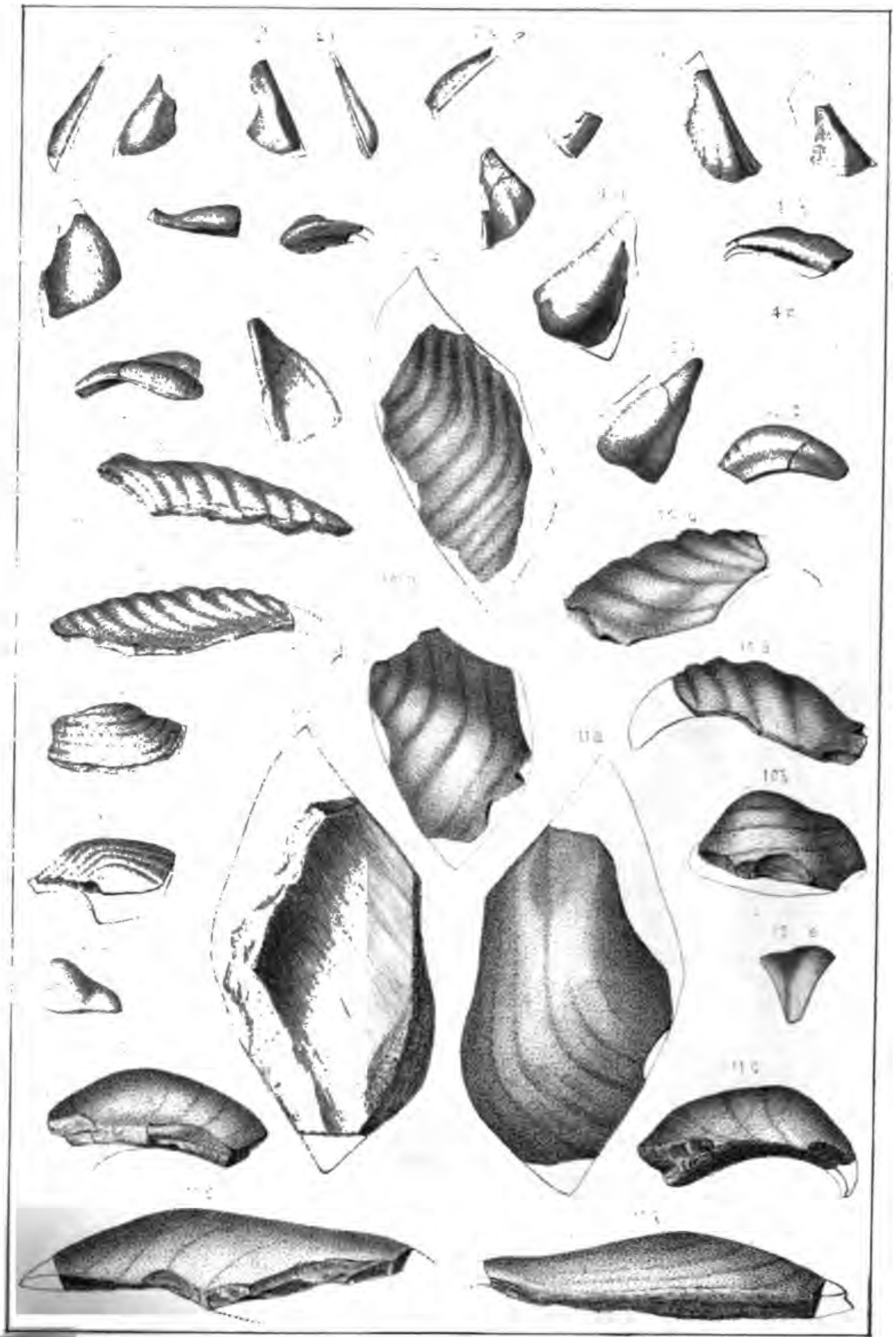
Fig. 11 *a*. Maxillary posterior tooth, left ramus, view from above, outline restored; 11 *b*. do., profile from inner margin; 11 *c*. do., outer inrolled margin; 11 *d*. do., from the antero-lateral border; 11 *e*. do., postero-lateral border; 11 *f*. do., inferior surface. Warsaw limestone; vicinity of Bedford, Indiana. O. St. John.

Fig. 12 *a*. Maxillary (?) posterior tooth, left ramus, seen from above, enlarged; 12 *b*. do., longitudinal profile from antero-lateral border; 12 *c*. do., postero-lateral border; 12 *d*. do., transverse profile from inner margin; 12 *e*. do., outer inrolled extremity; 12 *f*. do., inferior surface. Upper Burlington limestone, fish-bed; Pleasant Grove, Iowa.

PL. XIII

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. COCHLIODONTS.



O.S.J. del A.H. Worthen, Direxit J. Mayer & Co. lith Boston.

PLATE XIV.

Page.

Psammodus tumidus, St. J. and W. 206

Fig. 1 *a*. Maxillary tooth, right side, view from above, outline partially restored; 1 *b*, do., posterior margin; 1 *c*, do., inner articular border; 1 *d*, do., from the interior border. Upper Burlington; Buffington creek. Mr. St. John.

Fig. 2 *a*. Similar views of a smaller example of the same form, left side, partially restored outline. Same locality and collection.

Fig. 3 *a*. A larger, irregular example of the same form, right side, seen from above, outline restored, crown surface worn smooth; 3 *b*, do., inner articular border; 3 *c*, do., anterior margin. Same formation and locality. Mr. Springer.

Fig. 4 *a*. A broader tooth, referred to the mandible, right side, view from above, showing rugose belt along the posterior margin; 4 *b*, do., from the posterior margin; 4 *c*, do., inner articular border. Same formation, locality and collection.

Psammodus glyptus, St. J. and W. 209

Fig. 5 *a*. Mandibular tooth, right side, fragment seen from above, showing rugose coronal surface; 5 *b*, do., from the anterior margin; 5 *c*, from the articular or inner margin. Upper Burlington limestone, main fish-bed; Cedar creek, Illinois. Mr. Springer.

Fig. 6 *a*. Maxillary tooth, right (?) side, from above, the dotted line may possibly represent the proper restoration of the tooth; 6 *b*, do., posterior (?) margin; 6 *c*, do., profile section, showing the slight longitudinal convexity of the coronal surface. Upper Burlington limestone; Quincy, Illinois. Prof. Worthen.

Psammodus Lovianus, St. J. and W. 207

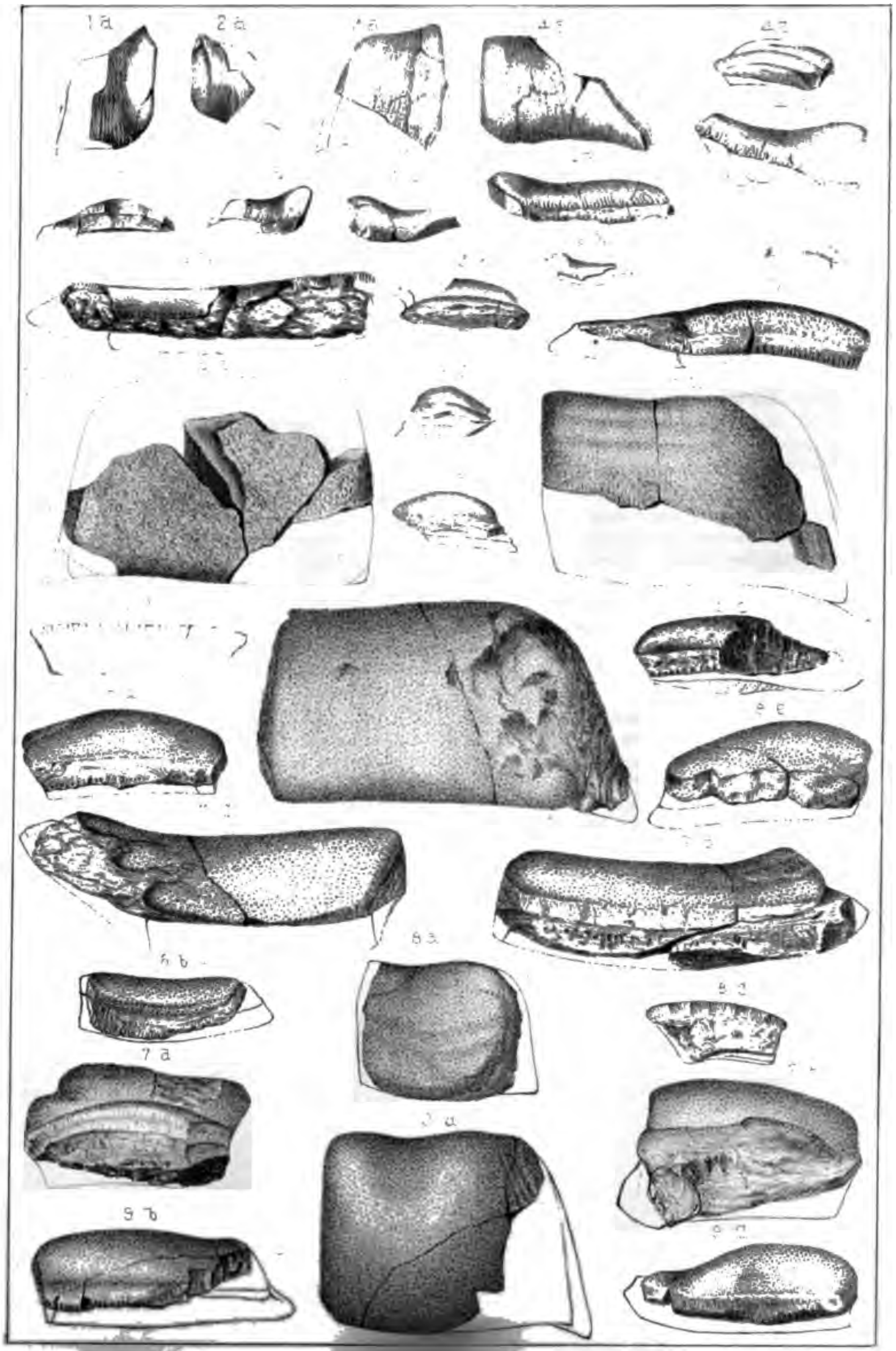
Fig. 7 *a*. Maxillary tooth, view from above; 7 *b*, do., from posterior margin; 7 *c*, do., anterior margin; 7 *d*, do., from the inner articular border; 7 *e*, do., exterior border. Upper Burlington; Burlington, Iowa. Mr. Wachsmuth.

Fig. 8 *a*. A small, narrow example of the same form, view from above, outline partially restored; 8 *b*, do., from the posterior margin; 8 *c*, do., profile section. Upper Burlington; Quincy, Illinois. Prof. Worthen.

Fig. 9 *a*. Mandibular tooth, right side, view from above, partially restored in outline; 9 *b*, do., transverse profile from posterior margin; 9 *c*, anterior margin; 9 *d*, do., articular border; 9 *e*, do., from the exterior border. Lower Burlington; Burlington, Iowa. Mr. St. John.

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (Lower Carb.) **PSAMMODONTS.**



Chas. K. Worthen, del.

PLATE XV.

PAGE.

PSAMMODUS GRANDIS, St. J. and W. 211

Fig. 1 *a*. **Mandibular tooth, from above, showing a fragment of a very large example, the triturating surface but slightly worn, restored in outline; 1 *b*. do., from the posterior margin; 1 *c*. do., anterior margin; 1 *d*. do., profile section. Keokuk; Keokuk, Iowa. Prof. Worthen.**

Fig. 2 *a*. **Maxillary tooth, view from above, outline restored, coronal surface worn during use; 2 *b*. do., from the posterior margin; 2 *c*. do., profile section. Keokuk; Keokuk, Iowa. Mr. Cox.**

Fig. 3 *a*. **A small worn example of the same form, view from above, outline partially restored; 3*b*. do., from the posterior margin; 3 *c*. do.' from the inner articular border. Keokuk; Bentonsport, Iowa. Mr. Springer.**

PSAMMODUS TURGIDUS, St. J. and W. 206

Fig. 4 *a*. **Maxillary tooth, view from above, outline partially restored; 4 *b*. do., from the posterior margin: 4 *c*. do., anterior margin; 4 *d*. do., inner articular border; 4 *e*. do., from the exterior border. U. B. limestone fish-bed; Des Moines county, Iowa.**

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (Lower Carb.) PSAMMODONTS.

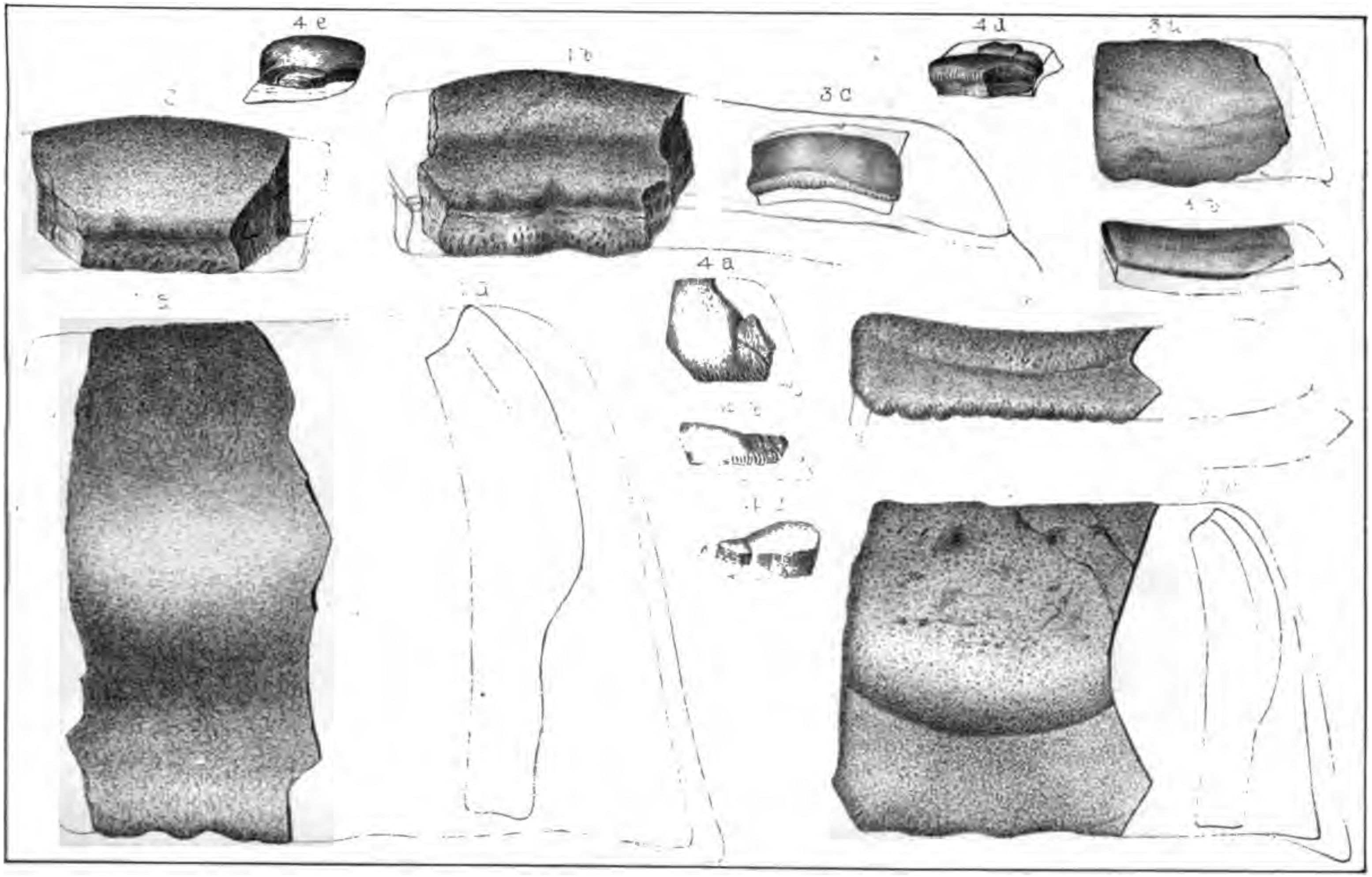


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PLATE XVI.

PAGE.

Fig. 1-4 PSAMMODUS PLENUS, St. J. and W. 213

1 *a*. Mandibular tooth, view from above; 1 *b*, do., from the articular border; 1 *c*, do., exterior border; 1 *d*, do., posterior margin; 1 *e*, do., anterior margin; *f*, do., inferior surface. St. Louis limestone; Alton, Ills. Mr. Van Horne.

2 *a*. A similar example of the same form, from above, outline partially restored; 2 *b*. do., inferior surface; 2 *c*, do., showing the channeled exterior border. St. Louis limestone; Monroe county, Ills. Prof. Worthen.

3 *a*, *b*. A nearly perfect specimen of the same form, view from above and the articular border, showing a faint marginal sulcation round the articular, posterior and anterior margins of the crown. St. Louis limestone; Alton, Ills. Mr. Van Horne.

4 *a*. View from above of a fragment of a very large maxillary tooth, partially restored in outline; 4 *b*, do., from the posterior margin; 4 *c*, do., articular inner border. St. Louis limestone; Alton. Mr. Alex. Butters.

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (Lower Carb.) **PSAMMODONTS.**

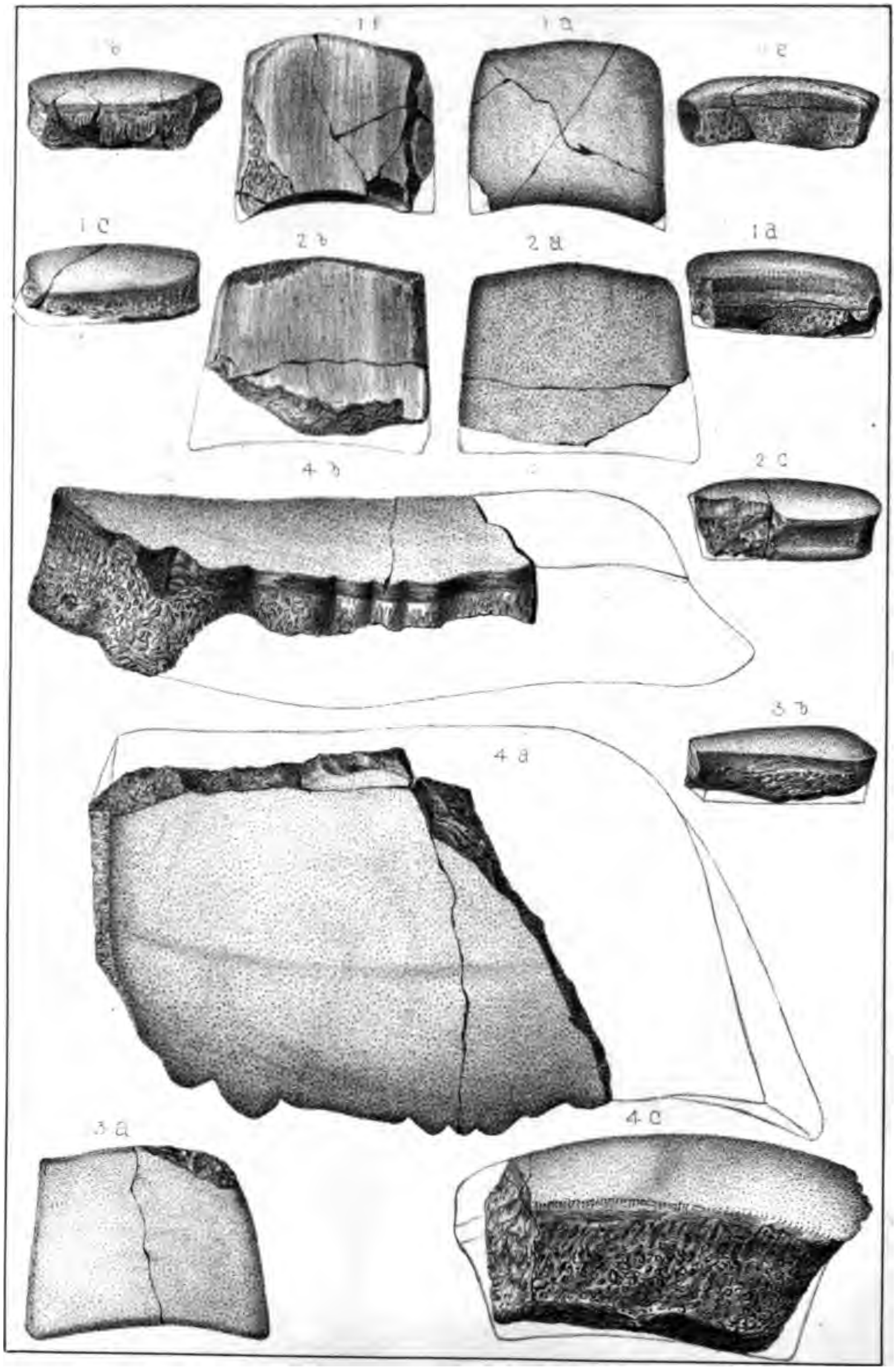

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PLATE XVII.

Page.

Psammodus plenus, St. J. and W. 213

Fig. 1 *a*. View from above of a small maxillary tooth; 1 *b*. do., posterior margin; 1 *c*. do., anterior margin, 1 *d*. do., inner articular border; 1 *e*. do., exterior border; 1 *f*. do., inferior surface. St. Louis limestone; Alton. Mr. Van Horne.

Fig. 2 *a*, *b*. *c*. *d*. *e*. *f*. Similar views of a medium-size example of the same form, outline partially restored. Alton; Mr. Van Horne.

Fig. 3 *a*. A larger specimen of the same form, view from above, showing more produced basal rim along the exterior border; 3 *b*. do., from posterior margin; 3 *c*. do., articular border; 3 *d*, do., exterior border. St. Louis limestone; Alton. Mr. Van Horne.

Fig. 4 *a*. A very wide mandibular tooth, from above; 4 *b*. do., from the posterior margin; 4 *c*. do., anterior margin; 4 *d*. do., longitudinal profile from the exterior border; 4 *e*. do., articular border. St. Louis limestone; St. Louis. Mr. St. John.

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. [illegible] PSAMMODONTS.

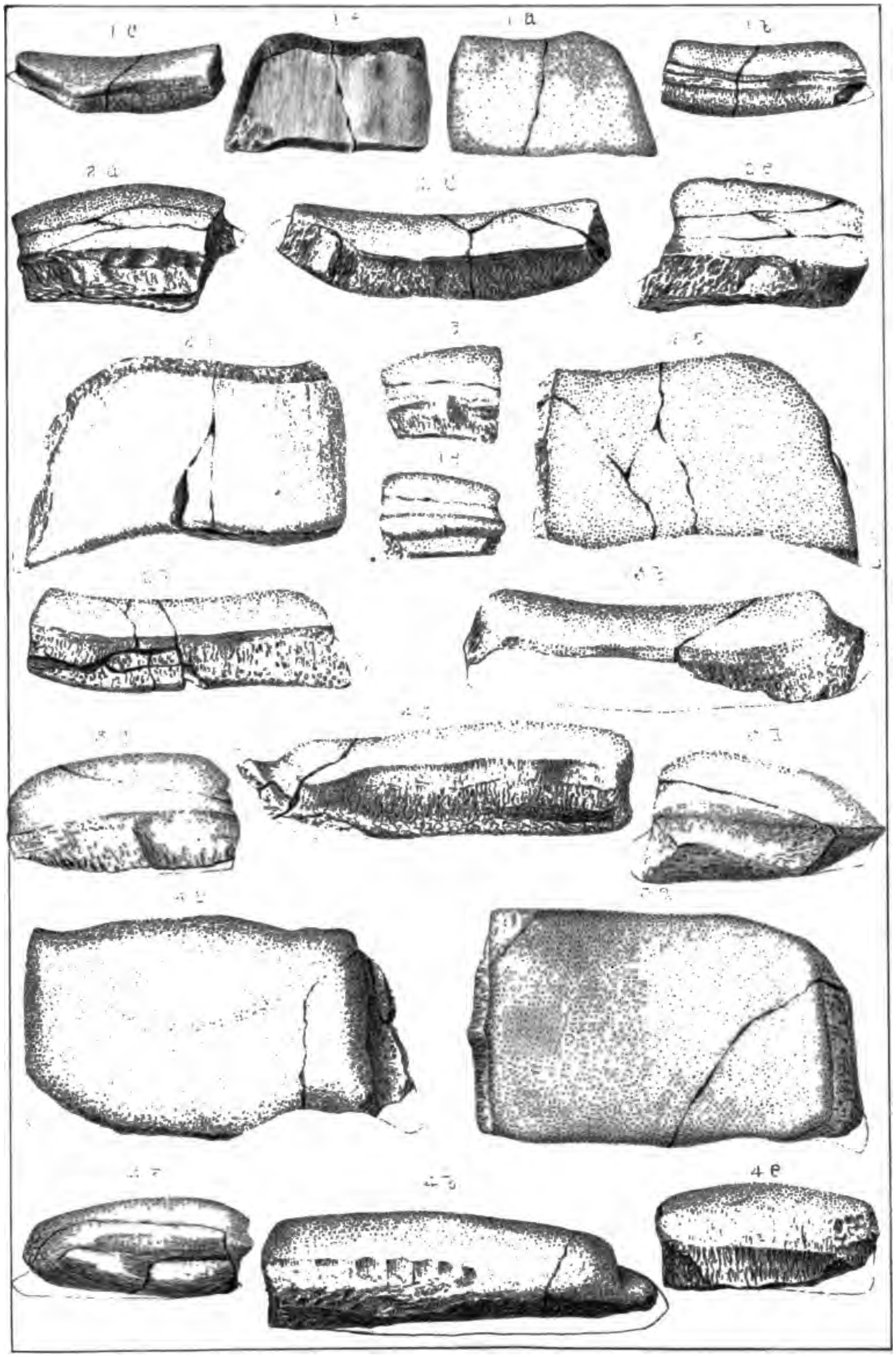

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PLATE XVIII.

PAGE.

PSAMMODUS CÆLATUS, St. J. and W. 217

Fig. 1 *a*. Maxillary tooth, view of triturating surface, inner articular border restored in outline; 1 *b*. do., exterior border; 1 *c*. do., posterior margin; 1 *d*. do., outline from anterior margin; 1 *e*. do., longitudinal profile section. St. Louis; Pella, Iowa. Mr. Van Horne.

PYAMMODUS CRASSIDENS, St. J. and W. 218

Fig. 2 *a*. A small tooth, showing the coronal surface worn smooth, view from above; 2 *b*. do., inner articular border; 2 *c*. do., exterior border; 2 *d*. do., posterior margin; 2 *e*. do., anterior margin. St. Louis; Pella, Iowa. Mr. St. John.

Fig. 3 *a*. A relatively shorter tooth of the same form, from above, preserving traces of the rugose coronal surface; 3 *b*. do., articular border; 3*c*. do., exterior border; 3 *d*. do., articular border; 3 *e*. do., posterior margin; 3 *f*. do., inferior surface; the dense external layer exfoliated. Original of "*Ps. rugusus*," Ill. Geol. Surv. II. Pl. XI. f. 3, 3. St. Louis; Alton, Ill. Professor Worthen.

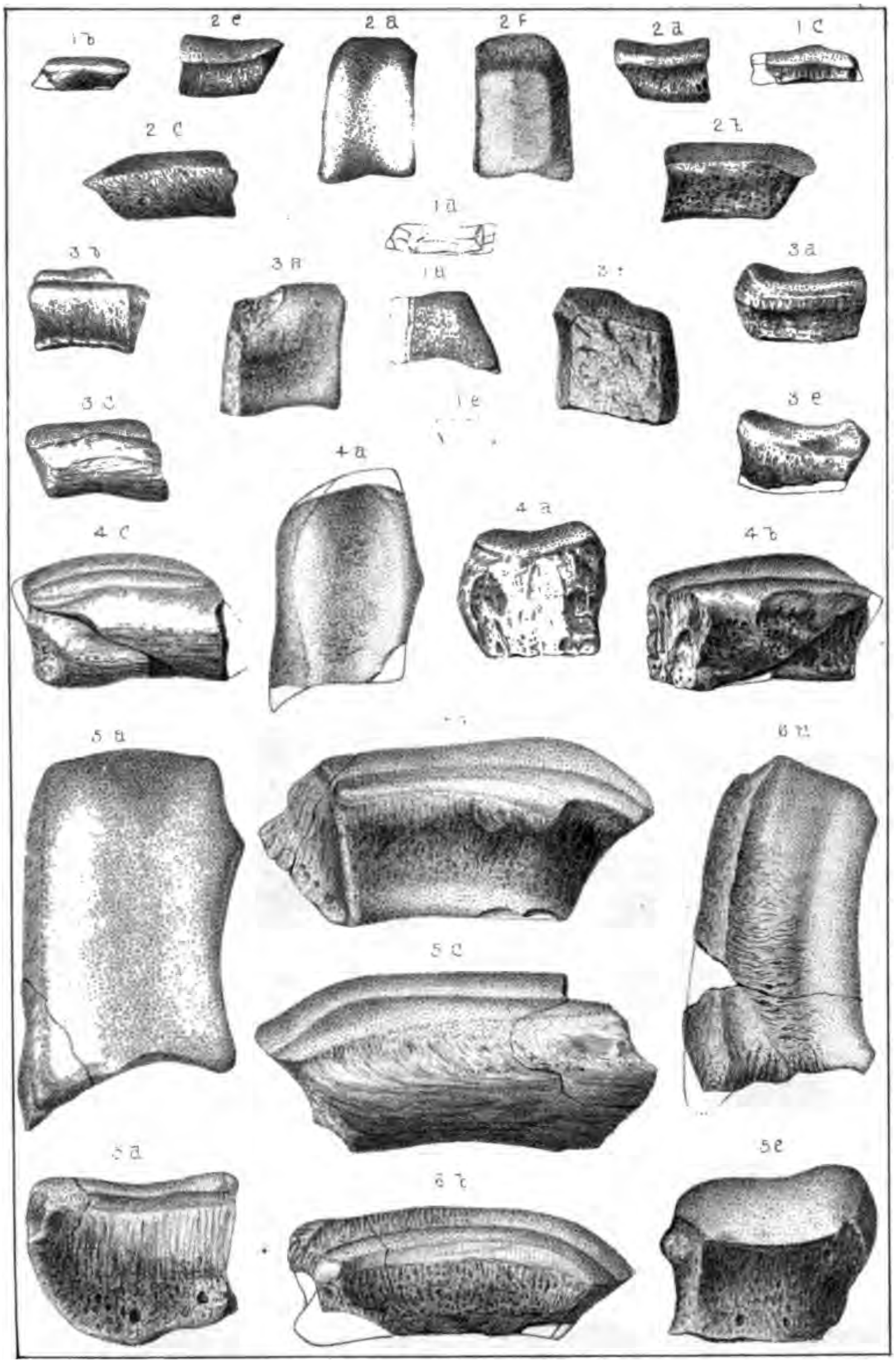
Fig. 4 *a*. A more elongate example of the same form, the triturating surface preserving traces of the transverse rugæ; 4 *b*. do., articular border; 4 *c*. do., exterior border; 4 *d*. do., posterior margin. St. Louis; Alton. Mr. Butters.

Fig. 5 *a*. A large entire example of the same form, the coronal region worn smooth, and showing the prominently developed basal rim of the exterior border; 5 *b*. do., articular border; 5 *c*. do., from the exterior border; 5 *d*. do., posterior margin; 5 *e*. do., anterior margin. St. Louis; Alton. Mr. Van Horne.

Fig. 6 *a*. An immature large tooth of the same form, the inner half of the coronal surface presenting beautiful rugose markings; 6 *b*. do., articular border. St. Louis; Alton. Mr. Butters.

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (Lower Carb.) **PSAMMODONTS.**



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GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (Lower [illegible]) **PSAMMODONTS.**

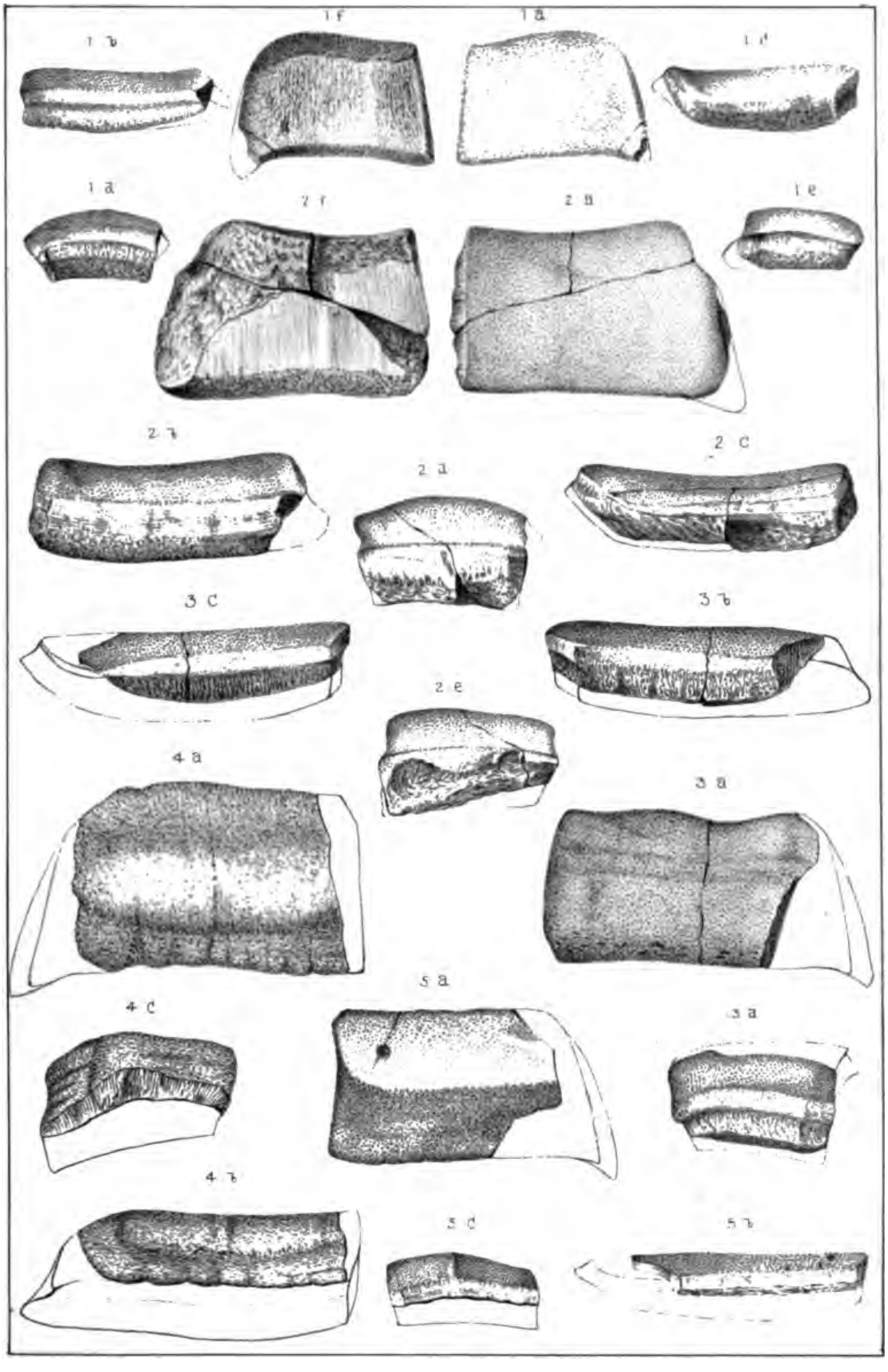

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PLATE XX.

Page.

Copodus pusillus, St. J. and W. 231

Fig. 1 *a*. Maxillary tooth, view from above, outline partially restored, enlarged; 1 *b*, do., transverse profile from inner margin; 1 *c*, do., longitudinal profile from the lateral border. Chester; Chester, Illinois. Dr. Geo. Hambach.

Copodus Van Hornii, St. J. and W. 229

Fig. 2 *a*. Mandibular tooth, view from above, outline partially restored; 2 *b*, do., from the outer margin; 2 *c*, do., longitudinal profile from the right border; 2 *d*, do., inferior surface. St. Louis; Alton, Ill. Mr. Van Horne.

Fig. 3 *a*. Maxillary tooth, from above; 3 *b*, do., from the anterior margin; 3 *c*, do., transverse profile from the posterior margin; 3 *d*, do., longitudinal profile from the left border; 3 *e*, do., inferior surface. St. Louis; St. Louis, Missouri. Mr. St. John.

Psammodus Springeri, St. J. and W. 202

Fig. 4 *a*. Maxillary tooth, right side, view from above; 4 *b*, do., transverse profile from inner margin; 4 *c*, do., anterior margin; 4 *d*, exterior border; outline showing probable disposition of teeth upon the jaw. Upper Burlington limestone fish-bed; Burlington. Mr. St. John.

Fig. 5 *a*, *b*, *c*. Similar views of a left side tooth of the same form; 5 *d*, do, articular border. Upper Burlington limestone; Louisa county, Iowa. Mr. St. John.

Fig. 6 *a*. View from above of a large example of the same form, outline partially restored; 6 *b*, do., transverse profile from posterior margin; 6 *c*, do., articular border. Upper Burlington fish-bed; Louisa county, Iowa. Mr. Springer.

Fig. 7 *a*. A similar example of the opposite side, from above; 7 *b*, do., exterior border; 7 *c*, do., articular border; 7 *d*, do., anterior margin. Same formation, locality and collection.

Fig. 8 *a*. Mandibular tooth, left side, from above; 8 *b*, do., posterior margin, transverse profile; 8 *c*, do., anterior margin; 8 *d*, do., articular border, longitudinal profile; 8 *e*, do., exterior border. Upper Burlington division beds; Quincy. Professor Worthen.

Fig. 9 *a*, *b*, *c*. Similar views of a specimen of the same form, right side; 9 *d*, do., articular border, and outline showing inrollment of the mandibular series of teeth from within outwards. Upper Burlington limestone; Burlington. Mr. St. John.

Fig. 10 *a*. Mandibular tooth, left side, view from above; 10 *b*, do., from posterior margin; 10 *c*, do., from anterior margin; 10 *d* from articular border; 10 *e* do., exterior border. Upper Burlington limestone; Louisa county, Iowa. Mr. Springer.

Fig. 11 *a*, *b*, *c*, *d*, *e*. Similar views of a large, proportionately broad mandibular(?)tooth, right side. Same formation, locality and collection.

VOL. VII PL. XX

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (Lower Carb.) PSAMMODUS &c.

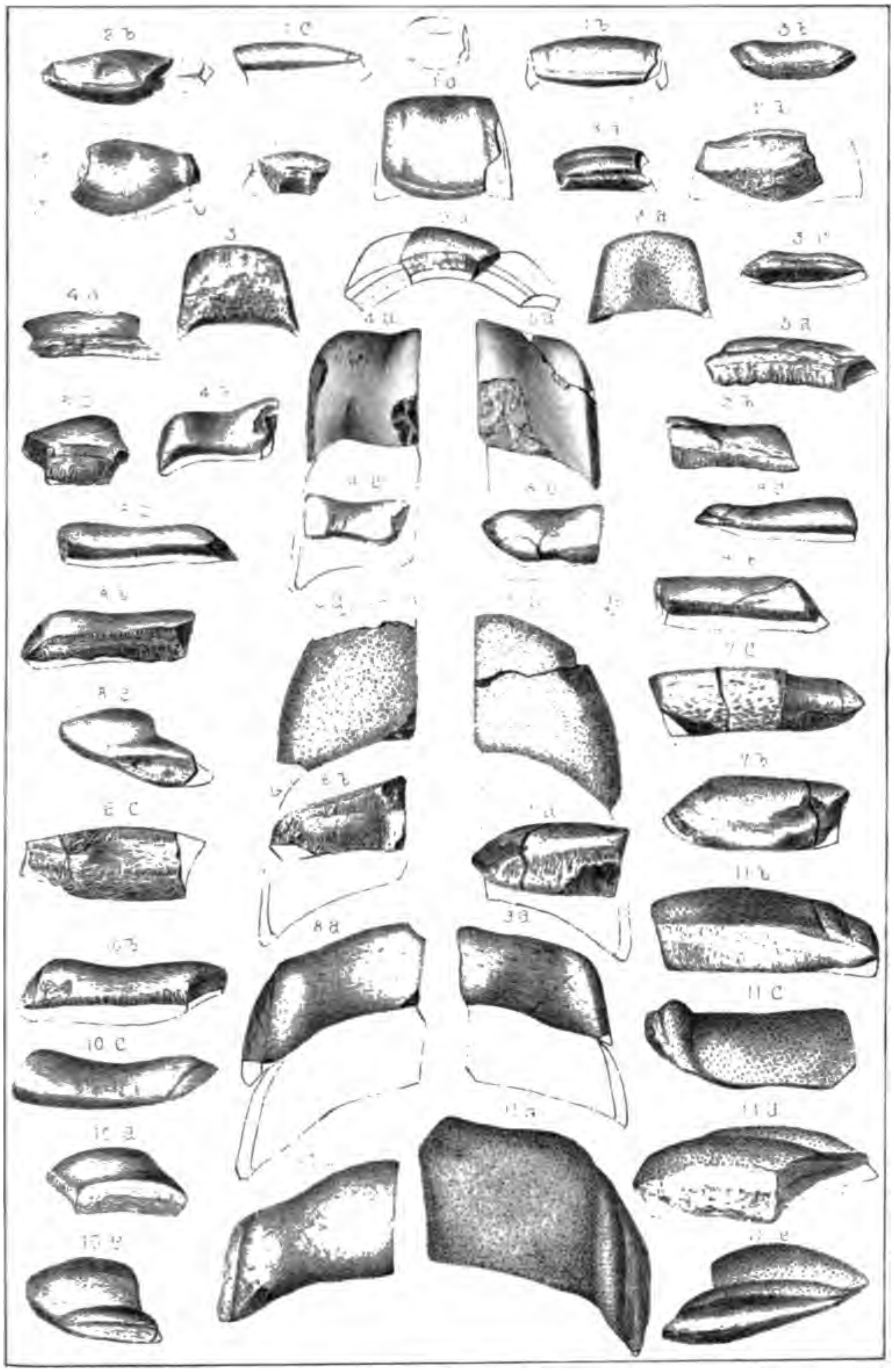

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PLATE XXI.

Page.

Ctenacanthus coxanus, St. J. and W. 233

Fig. 1 *a*. Side view of spine, outline restored; 1 *b*, do., showing anterior edge; 1 *c*, do., posterior face, the wall broken away exposing the pulp cavity; 1 *d*, do., transverse section near middle. Keokuk; Montrose, Iowa. Mr. Cox.

Ctenacanthus Pellensis 237

Fig. 2 *a*. Fragment of spine, showing the dorsal or anterior edge; 2 *b*, do., side view, outline partially restored; 2 *c*, do., posterior face, showing beveled lateral edges and the deep trough of the pulp cavity; 2 *d*, do., enlargement of surface, showing variable character of superficial ornamentation; 2 *e* do., cross section. St. Louis formation; Pella, Iowa. Mr. Van Horne.

Ctenacanthus cannaliratus, St. J. and W. 239

Fig. 3 *a*. Side view of fragment of spine; 3 *b*, do., anterior or dorsal edge; 3 *c*, do., posterior face; 3 *d*, do., transverse section. Chester; Chester, Ill. Dr. Hambach.

Asteroptychius tenellus, St. J. and W. 248

Fig. 4 *a*. Fragment of spine, view of left side; 4 *b*, do., enlargement of surface; 4 *c*, do., transverse section. Upper Coal Measures; Topeka. Mr. St. John.

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (L and U Carb.) ICHTHYODORULITES.

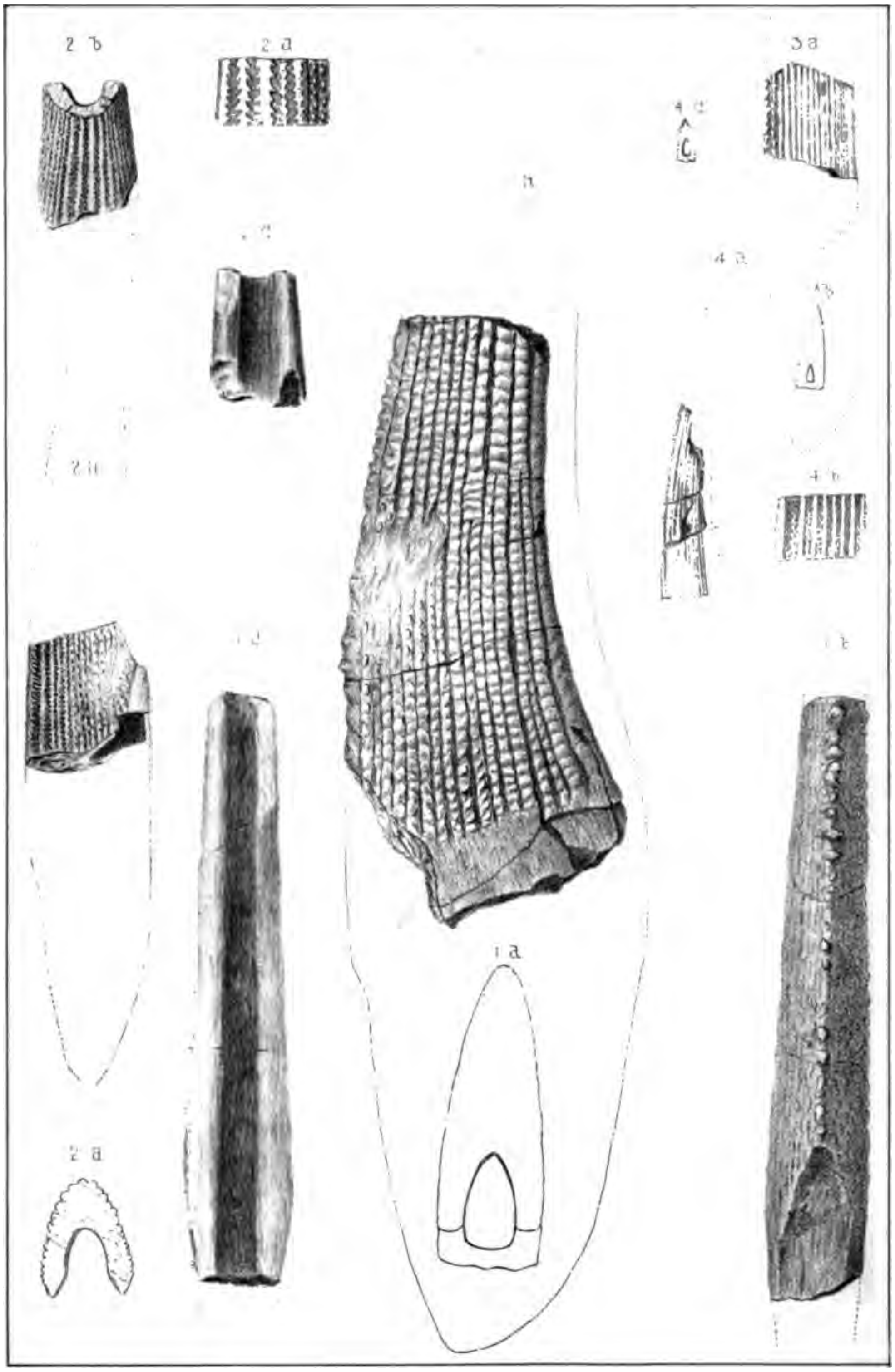

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PLATE XXII.

Page

Ctenacanthus deflexus, St. J. and W. 234

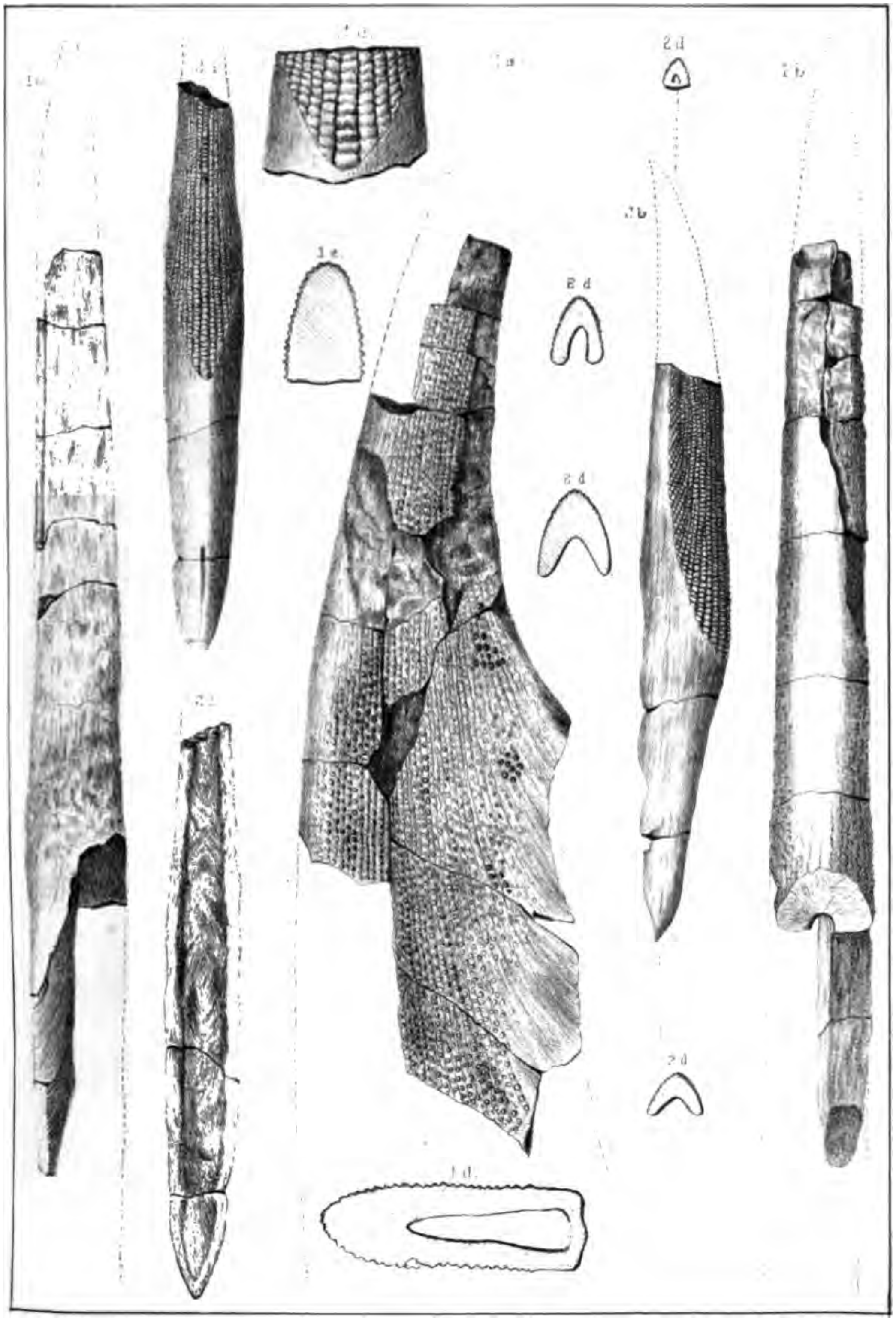
Fig. 1 *a*. Side-view of spine, outline partially restored; 1 *b*, do., showing the anterior edge: 1 *c*, do., posterior face; 1 *d*, *e*, do., transverse sections near the inferior angle of the posterior face and near the broken upper extremity. St. Louis; Alton, Ill., Mr. Alex. Butters.

Ctenacanthus Buttersi, St. J. and W. 240

Fig. 2 *a*. Dorsal view of spine; 2 *b*, do., view of right side; 2 *c*, do., showing posterior face; 2 *d*, do., cross sections from the middle and near the extremities; 2 *e*, do., enlargement showing tuberculated costæ in the basal angle in front, somewhat worn. Lower Coal Measures, Coal No. 5; Carlinville, Ill., Mr. Butters.

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. [illegible] **ICHTHYODORULITES.**



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GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (Lower Carboniferous) ICHTHYODORULITES.

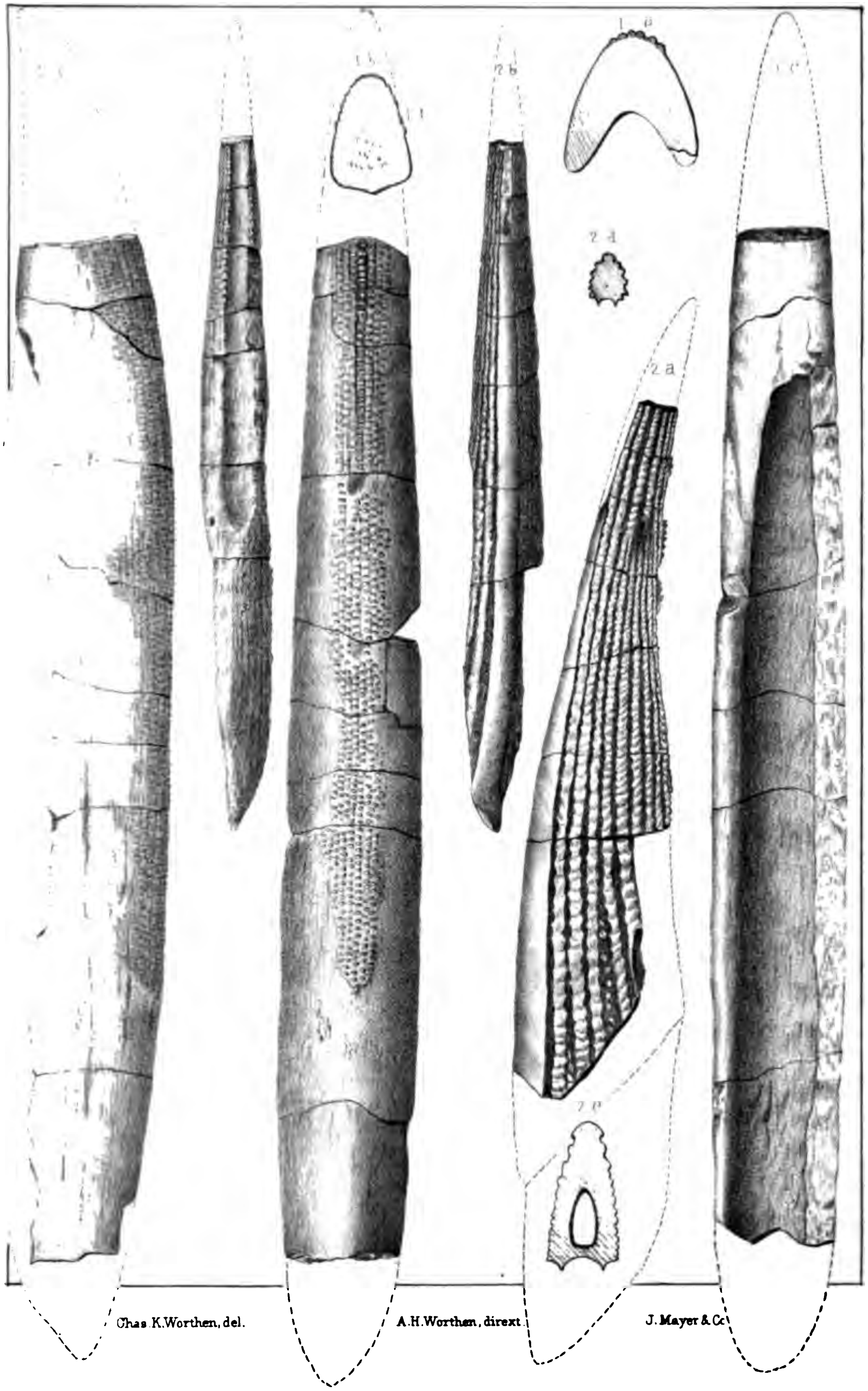

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PLATE XXIV.

PAGE.

CTENACANTHUS GRACILLIMUS, N. and W. 238

Fig. 1 *a*. Side view of a nearly entire dorsal spine. St. Louis limestone; Shumard collection of Washington University, St. Louis, Missouri.

ORACANTHUS VETUSTUS, Leidy 255

Fig. 2 *a*. View of right side of spine; 2 *b*, *c*, do., transverse sections toward tip and near middle, showing thickness of the walls inclosing pulp cavity; 2 *d*, do., enlargement of tubercle. St. Louis limestone, St. Louis, Missouri. Museum Washington University.

ACONDYLACANTHUS? MUDGIANUS, St. J. and W. 244

Fig. 3 *a*. View of fragment, showing a strip of the right side near the postero-lateral border with the longitudinal costæ, and part of the opposite side embedded in the limestone matrix, with the pulp cavity exposed to view; 3 *b*, do., transverse section of spine. Upper Coal Measures; Rock creek, near Manhattan, Kansas. Mr. St. John.

GYRACANTHUS? CORDATUS, St. J. and W. 251

Fig. 4 *a*. View of right side of spine, portion of inferior wall broken away exposing to view inner surface of the opposite wall; 4 *b*, do., transverse section near middle, the anterior border uppermost. St. Louis; Alton, Illinois. Mr. Butters.

DREPANACANTHUS REVERSUS, St. J. and W. 253

Fig. 5 *a*. View of right side of spine; 5 *b*, *c*, do., transverse sections toward tip and near dorsal line. St. Louis; Alton, Illinois. Mr. Butters.

PHYSONEMUS FALCATUS, St. J. and W. 252

Fig. 6 *a*. View of spine from the right side, base partially restored; 6 *b*, do., transverse section toward tip. St. Louis; St. Louis, Missouri. Washington University.

GEOLOGICAL SURVEY OF ILLINOIS

ICHTHYODORULITES. (L. and U. Carboniferous)

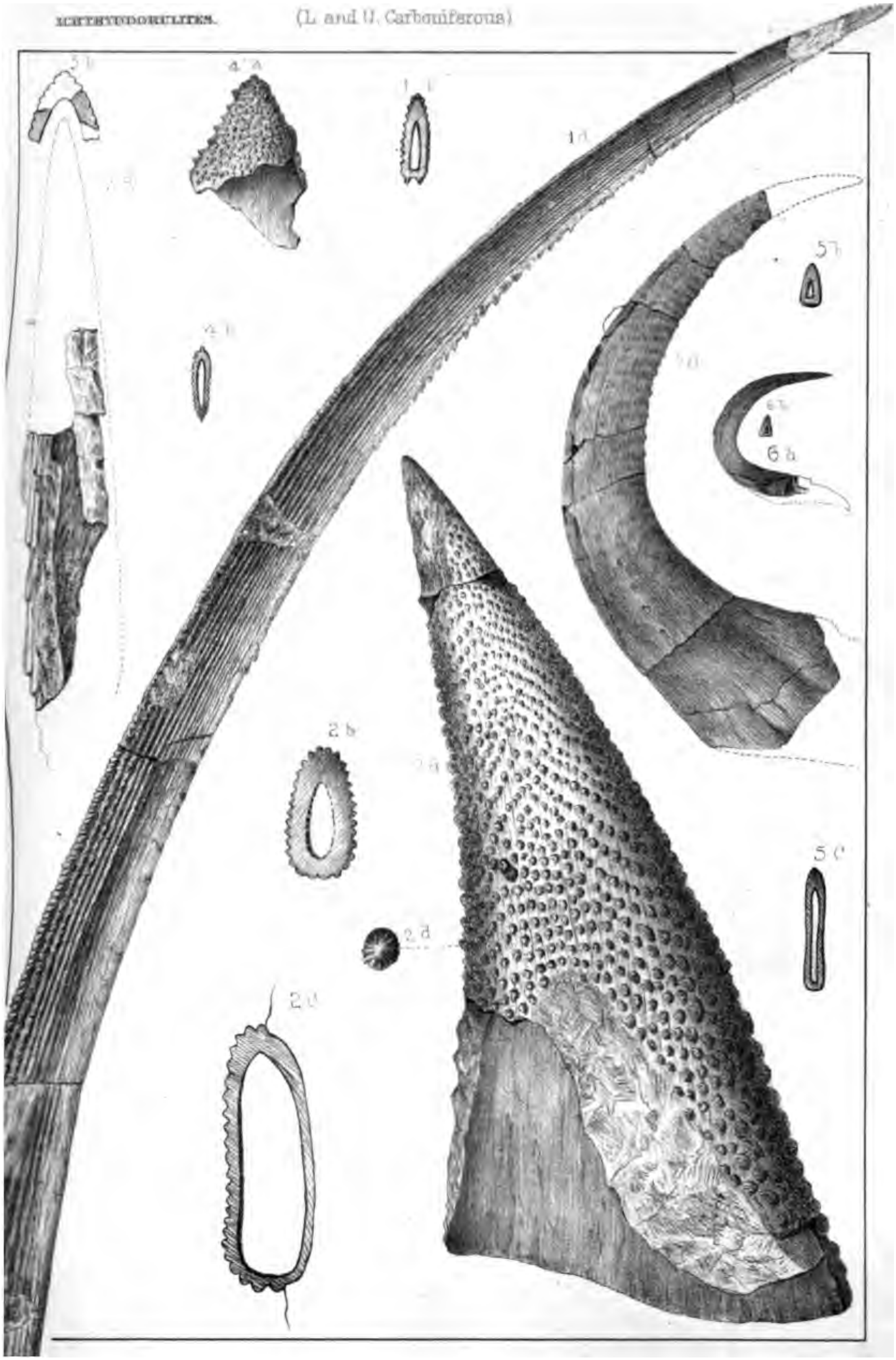

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PLATE XXV.

Page.

GLYMMATACANTHUS RUDIS, St. and W. 249

Fig. 1 *a*. View of fragment of spine from the right side, outline partially restored; 1 *b*, do., from the anterior border; 1 *c*, do., transverse section; Keokuk; Keokuk, Iowa. Mr. Cox.

GLYMMATACANTHUS PETRODOIDES, St. J. and W. 250

Fig. 2 *a*. View of fragment of spine, showing part of lateral surface tuberculation; 2 *b*, do., restored outline of transverse section; 2 *c*, do., enlargement, showing radiately-sculptured tubercles, as seen in profile. Chester; Chester, Illinois. Dr. Hambach.

ORACANTHUS RECTUS, St. J. and W. 257

Fig. 3 *a*. View of fragment of spine, showing portion of the posterior (?) border; 3 *b*, do., from the right (?) side; 3 *c*, do., in transverse section. restored. Chester; Chester, Illinois. Dr. Hambach.

BATACANTHUS ? NECIS, St. J. and W. 253

Fig. 4 *a*. View of spine from the left side, base restored in outline; 4 *b*, do., transverse sections near tip and at middle, the latter crushed in over the pulp cavity, with a restored section. Keokuk; Keokuk, Iowa. Mr. Cox.

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (L. and M. Carb.) **ICHTHYODORULITES.**

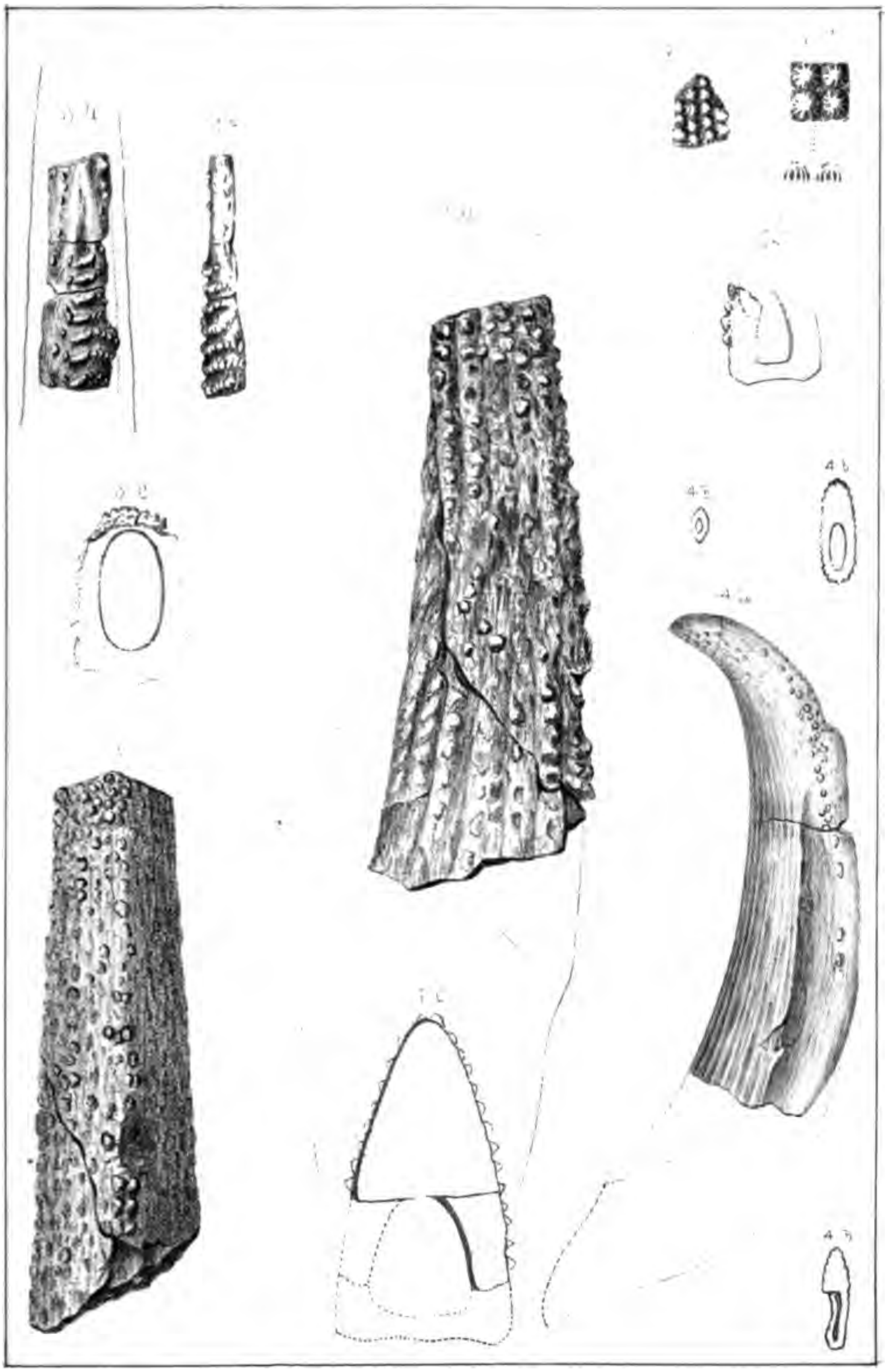

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PLATE XXVI.

PAGE.

ACONDYLACANTHUS? XIPHIAS, St. J. and W. 240

Fig. 1 *a*. View of right side of spine, the extremities and posterior border restored in outline; 1 *b*, do., transverse section near middle posterior face restored in outline. Keokuk; Keokuk, Iowa. Mr. Cox.

ACONDYLACANTHUS RECTUS, St. J. and W. 241

Fig. 2, *a*. View of spine from right side; 2 *b*, do., section of posterior face enlarged; 2 *c*, do., enlargement from middle of spine. Upper Coal Measures; LaSalle, Ill. Prof. Worthen..

ACONDYLACANTHUS NUPERUS, St. J. and W. 242

Fig. 3, *a*. View of spine from left side; 3 *b*, do., enlargement above middle of spine; 3 *c*, do., transverse section. Upper Coal Measures; Peru, Ill.. Mr. Tiffany.

GYRACANTHUS? CORDATUS, St. J. and W 251

Fig. 4 *a*. View of spine from the anterior edge, outline restored; 4 *b*, do., from the posterior face; 4 *c*, do., from the right side; 4 *d*, do., left side; 4 *e*, do., transverse sections at different parts of the spine, the posterior wall destroyed at both extremities, as shown in figure 4 *b*. Keokuk; Keokuk, Iowa. Mr. Cox.

GEOLOGICAL SURVEY OF ILLINOIS

FOSSIL FISHES. (L and U Carb.) ICHTHYODORULITES.

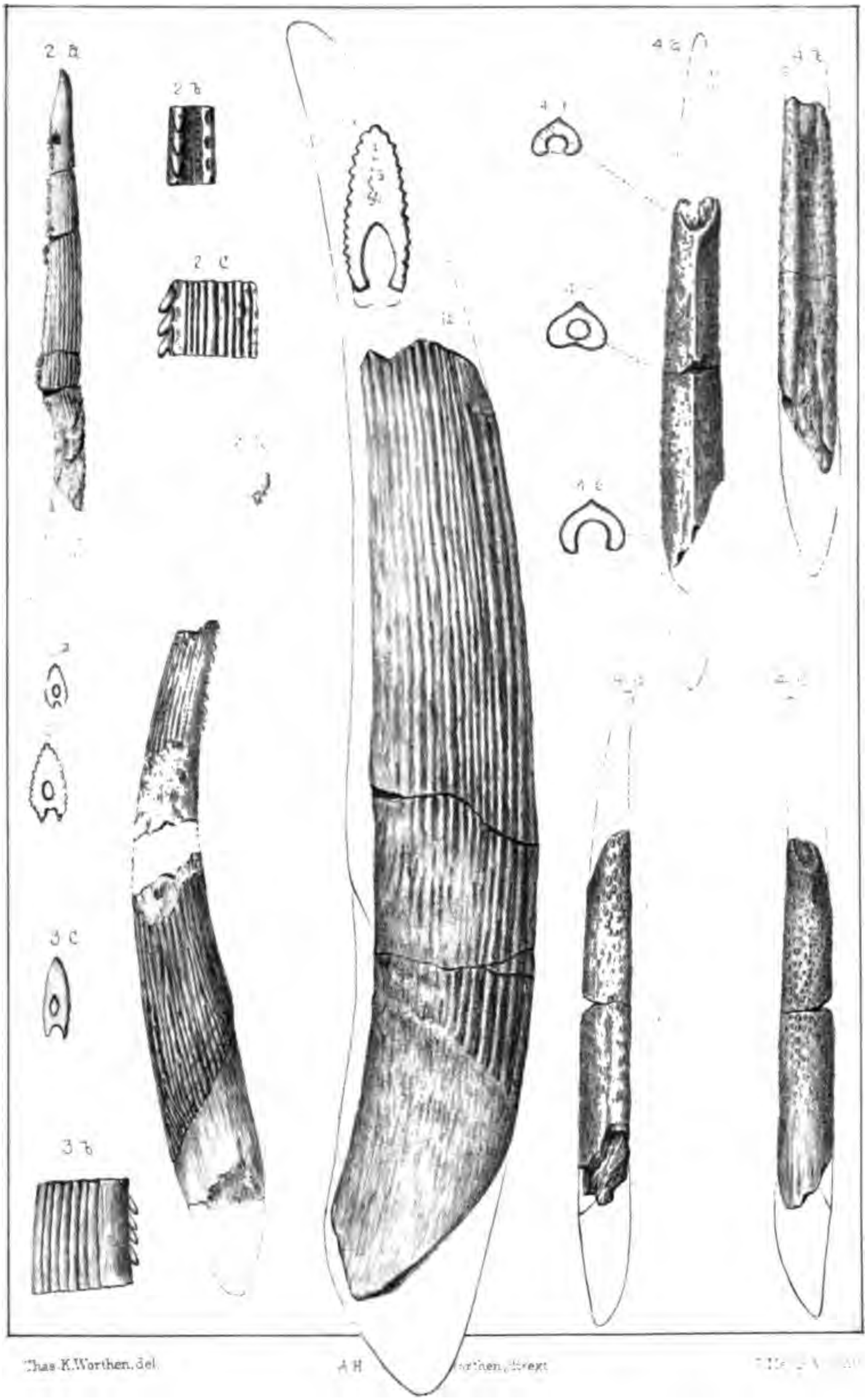

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PLATE XXVII.

Page.

Fig. 1. **Poteriocrinus Coxanus** 269
Anterior view of the body, and the upper part of the ventral tube; natural size.

Fig. 2. **Poteriocrinus occidentalis** 278
Side view of the type specimen, showing the anal plates, arms, and a part of the column; natural size.

Fig. 3. **Poteriocrinus Orestes** 273
Anterior view, showing the arms and tentacula.
3 *a*. Posterior view of the same; natural size.

Fig. 4. **Poteriocrinus briærius** 279
Posterior side, showing the arms and tentacula.
4 *a*. Anterior view of another individual; natural size.

Fig. 5. **Rhodocrinus polydactylus** 305
Posterior view; natural size.

Fig. 6. **Poteriocrinus subramulosus** 284
Anterior view of body and arms; natural size.

Fig. 7. **Dichocrinus Coxanus** 313
Anterior view of body and arms; natural size.

Fig. 8. **Poteriocrinus asper** 278
Anterior view of body and arms; natural size.

Fig. 9. **Poteriocrinus Hamiltonensis** 273
Posterior view of the body, arms and tentacula; natural size.

Fig. 10. **Dichocrinus Hamiltonensis** 313
Anterior view; natural size.

GEOLOGICAL SURVEY OF ILLINOIS

CRINOIDS. (Lower [illegible] **KEOKUK GR.**

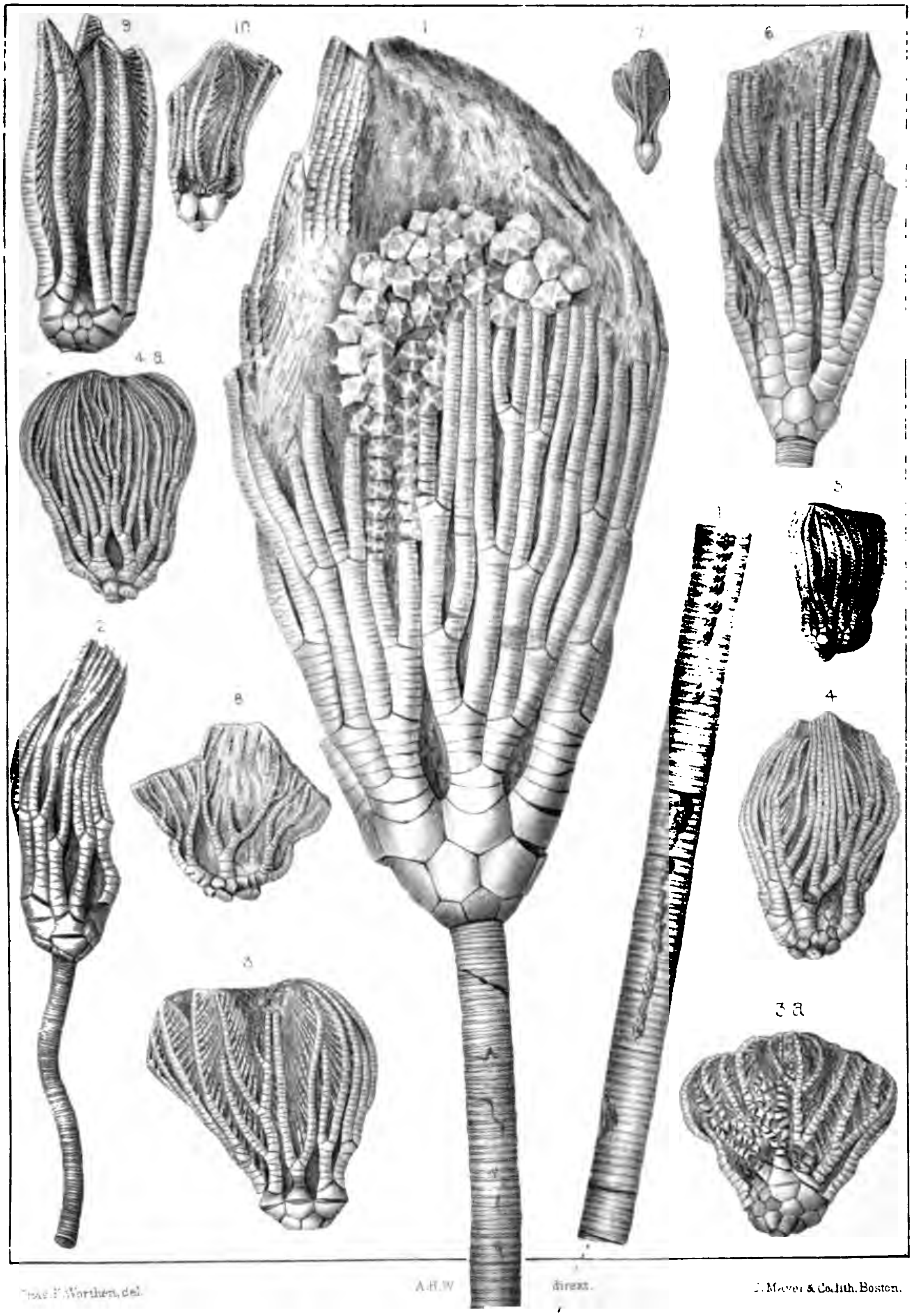

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PLATE XXVIII.

Page.

Fig. 1. Zeacrinus Coxanus ... **302**

Anterior view of the body, arms and tentacula, and a portion of the column, natural size.

Fig. 2. Poteriocrinus asperatus ... **280**

Posterior view of the body, arms and tentacula, and a portion of the column, natural size.

Fig. 3. Zeacrinus Keokuk ... **303**

Anterior view of body and arms, natural size.

Fig. 4. Poteriocrinus Otterensis ... **283**

Side view of a crushed specimen, and a part of the pentagonal column.

Fig. 5. Cyathocrinus parvibrachiatus ... **309**

Anterior view of the body, arms, and a part of the column, natural size.

Fig. 6. Poteriocrinus latidactylus ... **275**

Side view of the body, a part of the arms, and upper portion of the column, natural size.

Fig. 7. Rhodocrinus Coxanus ... **305**

Posterior view, natural size.

Fig. 8. Poteriocrinus Burketi ... **270**

Anterior view of body and arms.

8 *a*. Posterior view of another individual showing the ventral tube and column.

Fig. 9. Poteriocrinus penicilliformis ... **276**

Posterior view of a nearly perfect individual, natural size.

Fig. 10. Poteriocrinus Nauvooensis ... **282**

Side view of a crushed specimen, natural size.

Fig. 11. Poteriocrinus tentaculatus ... **277**

Posterior view, natural size.

Fig. 12. Poteriocrinus arachnæformis ... **281**

Posterior view of the body and a portion of one of the arms, natural size.

Fig. 13. Poteriocrinus tenuidactylus ... **271**

Anterior view of the body and a part of the arms, natural size.

Fig. 14. Eretmocrinus Varsoviensis ... **306**

Side view of the body with arms complete, and a part of the column, natural size.

Fig. 15. Poteriocrinus Varsoviensis ... **290**

Side view of the body and a part of the arms and column, natural size.

Fig. 16. Poteriocrinus validus ... **287**

Anterior view of the body and a part of the arms and column, natural size.

Fig. 17. Poteriocrinus Illinoiensis ... **289**

Posterior view of the body and part of the arms, natural size.

GEOLOGICAL SURVEY OF ILLINOIS

CRINOIDS. (Lower Carb.) **KEOKUK & WARSAW.**

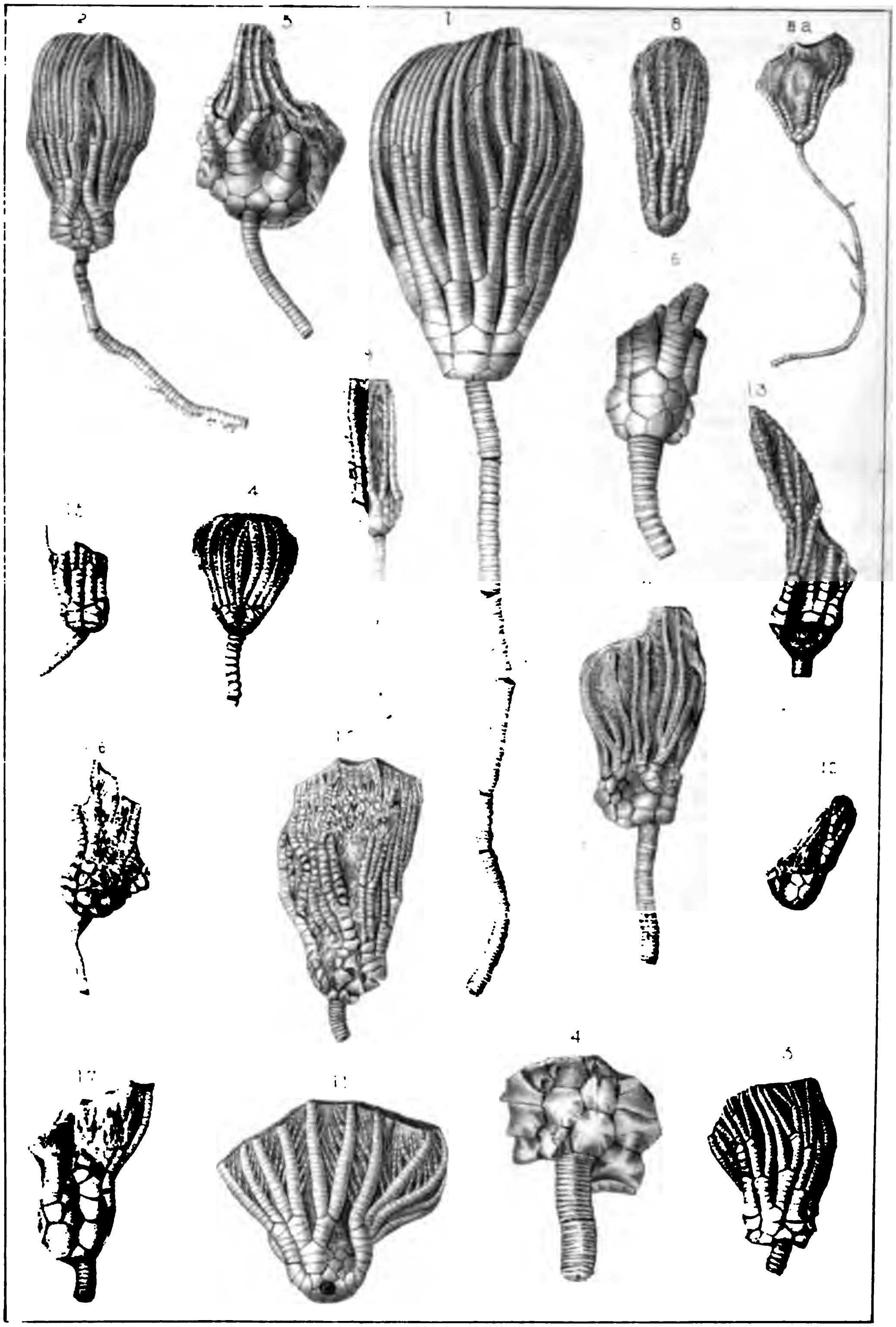

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PLATE XXIX.

PAGE

Fig. 1. **Poteriocrinus spinobrachiatus** 290
Anterior view of a nearly perfect specimen.

Fig. 2. **Poteriocrinus Okawensis** 296
Side view showing body and two of the arms.

Fig. 3. **Eupachycrinus Boydi.**
Side view of a nearly perfect specimen.
For description of this species see Vol. V. of these Reports, p. 554.

Fig. 4. **Eupachycrinus asperatus** 311
4 *a*. Side view of the body and lower part of the arms.
4 *b*. Basal view of the same specimen.

Fig. 5. **Onychocrinus distensus** 307
Side view of the body and lower part of the arms.

Fig. 6. **Poteriocrinus Columbiensis** 293
Side view of a nearly perfect individual.

Fig. 7. **Agassizocrinus hemisphericus** 316
7 *a* and 7 *b*. Opposite sides of the same specimen.
7 *c*. Basal view of the same.

Fig. 8. **Poteriocrinus sculptus** 292
Side view of the body and lower part of the arms.

Fig. 9. **Poteriocrinus propinquus** 299
Side view of the body and a portion of the arms and column.

Fig. 10. **Poteriocrinus peculiaris** 298
10 *a*. Anterior side, with the arms nearly complete.
10 *b*. Posterior side of another specimen.

Fig. 11. **Talarocrinus ovatus.** 314
11 *a*. Side view. 11 *b*. Basal view.

Fig. 12. **Poteriocrinus Popensis** 296
Side view of the body and arms.

Fig. 13. **Poteriocrinus venustus** 297
13 *a*. Posterior side of a nearly perfect individual.
13 *b*. Anterior view of the same specimen.

Fig. 14. **Allagecrinus Carpenteri** 341
Side view of a nearly perfect individual.

Fig. 15. **Poteriocrinus Kaskaskiensis** 300
Side view of a nearly perfect individual.

Fig. 16. **Eupachycrinus Monroensis** 312
Basal view.

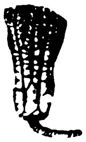
Fig. 17. **Agassizocrinus papillatus** 315
Side view of the body and arms.

Fig. 18. **Poteriocrinus Salteri** 291
Side view of a nearly perfect specimen.

GEOLOGICAL SURVEY OF ILLINOIS

CRINOIDEA. CHESTER LIMESTONE.

18



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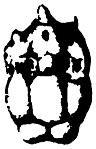

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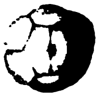

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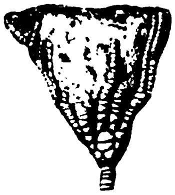

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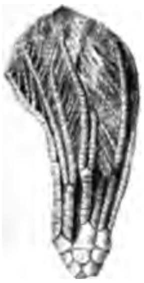

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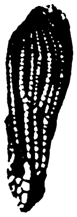

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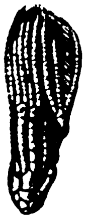

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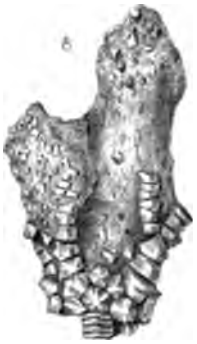

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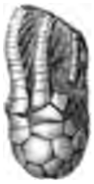

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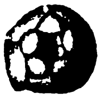

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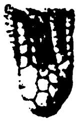

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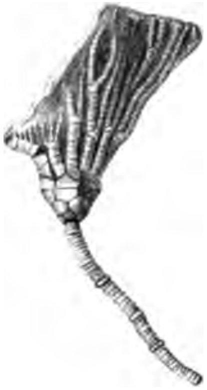

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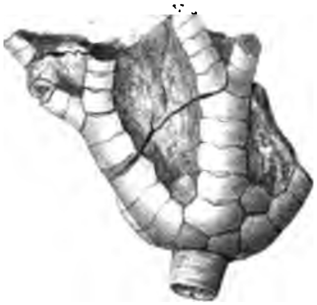

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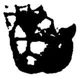

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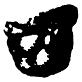

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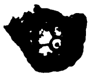

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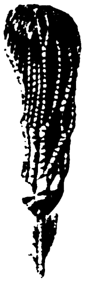

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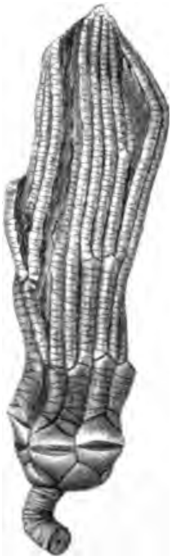

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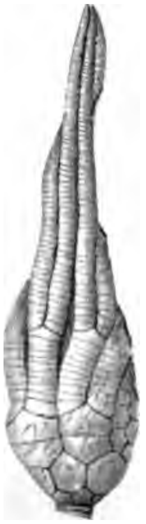

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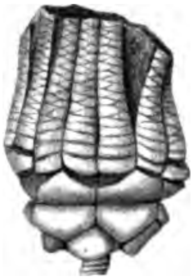

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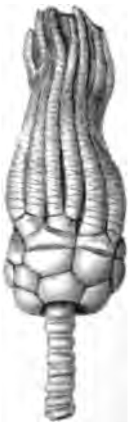

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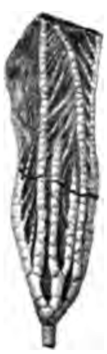

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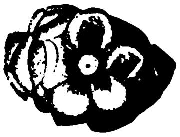

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PLATE XXX.

Page.

Fig. 1. Poteriocrinus cultidactylus 301
View of the anal side.

Fig. 2. Taxocrinus Fletcheri 308
View of a nearly perfect individual.

Fig. 3. Zeacrinus Pikensis 304
Side view of a nearly perfect individual.

Fig. 4. Cyathocrinus Marshallensis 310
Side view of a nearly perfect individual.

Fig. 5. Peteriocrinus Richfieldensis 285
View of the anal side of the body and the arms complete.

Fig. 6. Poteriocrinus Claytonensis 288
Side view of the body with part of the arms and column.

Fig. 7. Poteriocrinus Talboti 287
Side view of the body and part of the arms.

Fig. 8. Lecythiocrinus Adamsi 317
8 *a*, and 8 *b*. Opposite sides of the same specimen.
8 *c*. View of the summit. 8 *d*. View of the base.

Fig. 9. Platycrinus Monroensis 306
Side view of body and arms.

Fig. 10. Poteriocrinus clytis 294
Side view of a nearly perfect individual.

Fig. 11. Poteriocrinus Fountainensis 286
View of the anal side and part of the arms.

Fig. 12. Poteriocrinus similis 295
Side view of a nearly perfect specimen.

Fig. 13. Acrocrinus Wortheni 343
13 *a* and 13 *b*. Opposite sides of the body.

Fig. 14. Archæocidaris spino-clavatus 337
14 *a*, *b*, *c*. Primary spines.
14 *d*, *e*. Interambulacral plates.

Fig. 15. Archæocidaris Edgarensis 337
15 *a*, *b*. Primary spines.
15 *c*. Interambulacral plates.

Fig. 16. Jaw plates of Archæocidaris? sp. undt ....
From the Upper Coal-Measures, LaSalle, Ill.

GEOLOGICAL SURVEY OF ILLINOIS

CRINOIDEA & ECHINOIDEA.

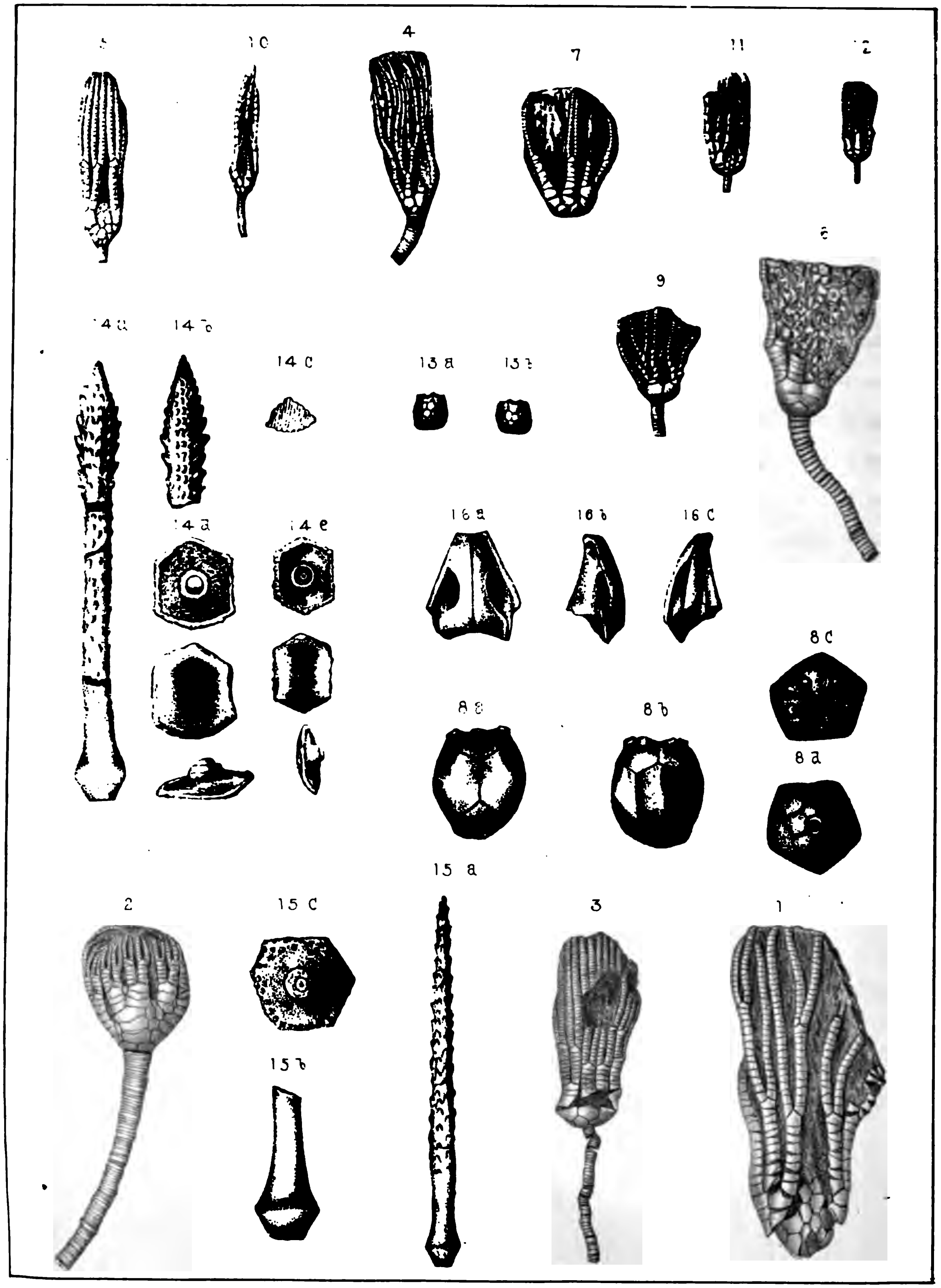

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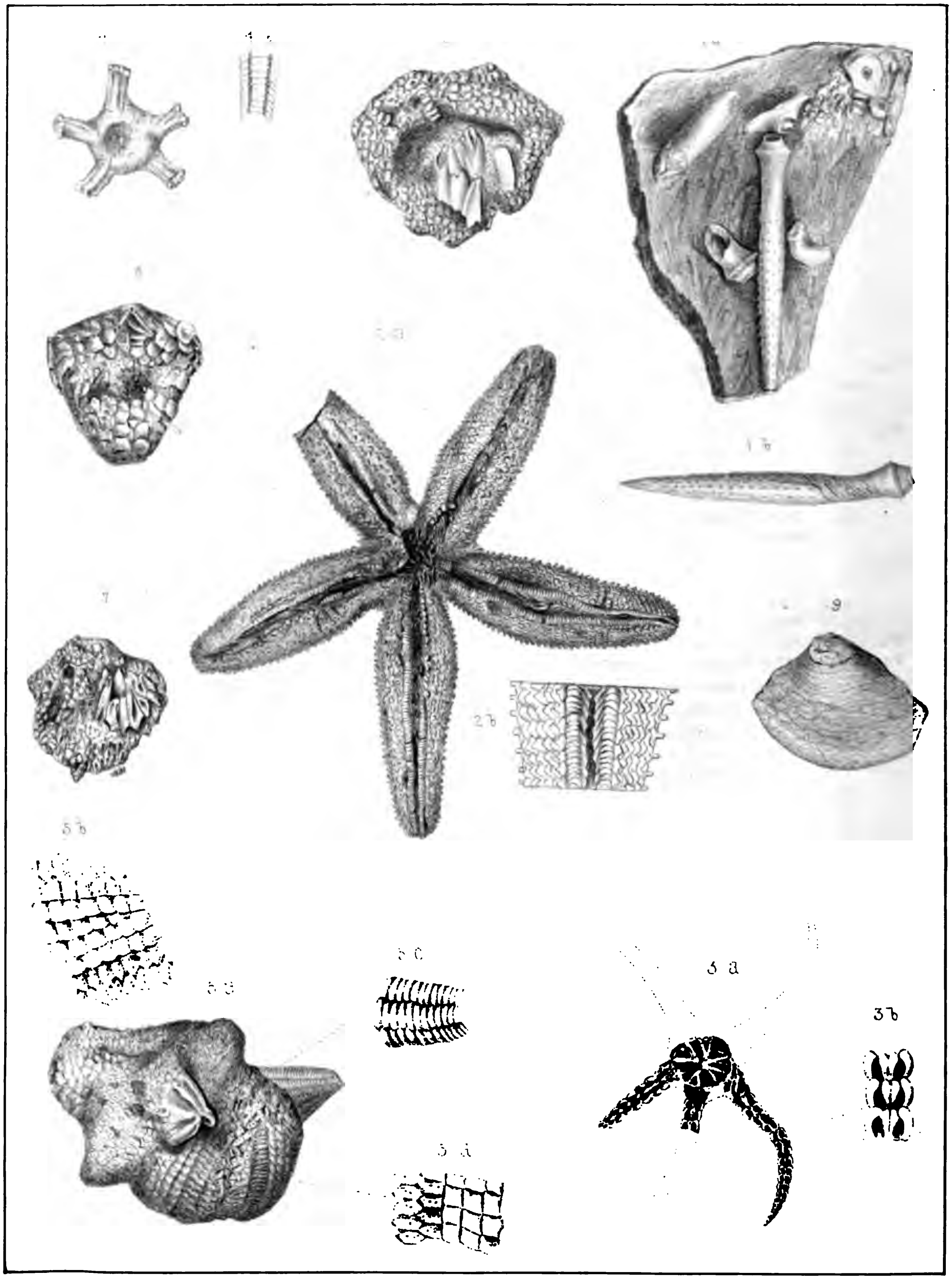
PLATE XXXI.

		PAGE.
Fig. 1.	Archæocidaris Illinoiensis	338
1 *a*, *b*.	Primary spines natural size.	
Fig. 2.	Compsaster formosus	327
2 *a*.	Ventral side natural size.	
2 *b*.	Section of ray enlarged two diameters.	
Fig. 3.	Tremataster difficilis	330
3 *a*.	Ventral side magnified two diameters.	
3 *b*.	Section of ray magnified four diameters.	
Fig. 4.	Cholaster peculiaris	329
4 *a*.	Dorsal view natural size.	
4 *b*.	Section of ray magnified two diameters.	
Fig. 5.	Hybochinus spectabilis	332
5 *a*.	View of a depressed specimen natural size.	
5 *b*. *d*.	Views of ambulacral and adambulacral plates, enlarged two diameters.	
5 *c*.	Magnified view of horn-like protuberance.	
Fig. 6.	View of a crushed specimen, showing the jaws.	
Fig. 7.	Jaws, belonging to this or a kindred species.	
Fig. 8.	Perischodomus Illinoiensis	333
	View of the apical end of a distorted specimen, natural size.	
Fig. 9.	Echinodiscus optatus	336
	View of part of the lower side of a specimen, showing the plates near the margin, natural size.	

GEOLOGICAL SURVEY OF ILLINOIS

ECHINOIDEA. ST. LOUIS & CHESTER GROUPS.



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